APRIL 1950

Chemical Engineering Progress

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

WEATHER WORRIES?

GET RID OF THEM WITH THE

Wiggins Gasholder

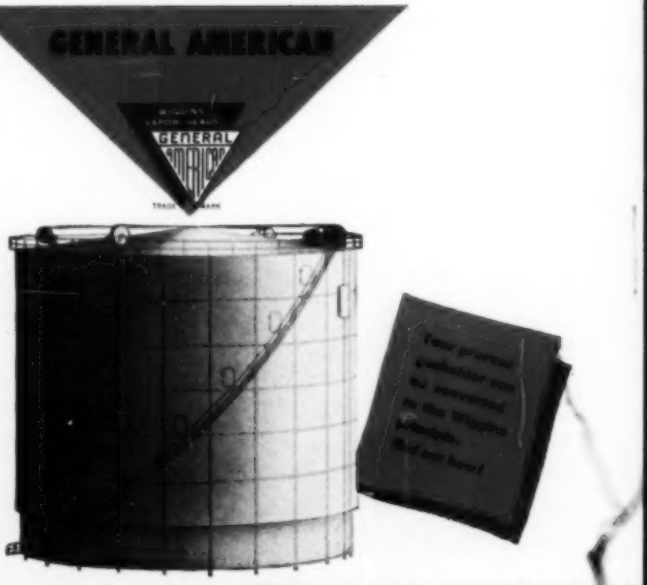
BY

GENERAL AMERICAN

Let the summer sizzle up to 110°. Let winter whip down to 50° below. No matter how extreme the temperatures, they can't bother the Wiggins Gasholder. Yes, it's basically different from all others, using an absolutely DRY, frictionless seal—proved gas-tight and impermeable by 15 years' use.

"Freeze-ups" are impossible—because there's no water to freeze, no tar, no grease to dehydrate. In the burning heat of summer, moisture can't adulterate stored gases—because there's no water to evaporate. Gases stay dry, pure, undiluted.

Impressive savings are obvious: Wiggins Gasholder design does away with need for steam coils, winter heating. No anti-freeze is required. Operating costs go down to zero—with no need for constant inspection and maintenance of seals. *Remote operation is now possible!* Absence of water or other sealant liquid permits construction with no heavy or complicated rigging. Even the foundation is lighter, for there is no heavy load of water to support. The Wiggins Gasholder is built to withstand heat, cold, ice, snow, wind, rain—and earthquakes! Operates at any pressure up to 20" of water. Write for complete technical facts.



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Like to barn-dance, eat sea-food, visit historical spots, or talk chemical engineering? Then plan to attend the A.I.Ch.E. Swampscott Regional Meeting, May 28-31, 1950. Parts of the technical program are printed on page 13 in the news section, and within a few weeks, A.I.Ch.E. members will receive a complete program through the mail. Nonmembers can secure a copy for this regional meeting from the Secretary's office, 120 East 41st Street, New York 17, N. Y.

The Engineering Licensing Symposium which was given at Pittsburgh and drew so large an attendance there, begins in this issue. The audience discussion will make up the second part of the symposium and will be printed in our May issue.

The Constitutional Amendments of the A.I.Ch.E. were all approved by the members by a more than 5 to 1 vote. Results of the balloting are given by the Secretary on page 36. The proposal to create a student-member grade within the Institute, was the most popular, only 91 voting against it.

For those who want the latest literature on equipment and chemicals in the process field, use the Data Service card following page 28.

For a brief résumé of the recent Houston Regional Meeting and pictures of some of the speakers and committee members who made this meeting the success it was, see page 18.

Good chemical engineers are always needed. In the Classified Section this month, there is call for a process engineer, a project engineer, a chemist for a heavy-chemical plant and an engineer for technical liaison work.

For employers who are anxious to reach the best men in chemical engineering, we suggest they use our Classified Section. Membership in the A.I.Ch.E. we think, is in itself an indication of proficiency, and first-class men are usually available through our columns.

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Number 4

Chemical Engineering Progress

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1950

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For Your Information

WOOD, used in construction of this Italian Pergola in world-famous Missouri Botanical Gardens in St. Louis, was treated with a formulation of Monsanto's PENTA-chlorophenol to give it longer life. Wood, including redwood, Douglas fir and cypress, was treated to prevent attack by fungi and insects. And, in this example of Italian art, treated wood had to be paintable.

Look into this New Monsanto Product

Here's a new Monsanto product that may be of use to industry. It is phosphorous acid . . . H_3PO_3 . . . a mild reducing agent. It is a stable, water-white, 70% water solution suitable for the manufacture of a variety of phosphite salts. It is available for immediate shipment in 13-gallon carboys. Send for Monsanto Technical Bulletin No. P-32 and see if this product fits into your production or research picture. The coupon is for your convenience.

How to cut costs without cutting quality of vinyls

The use of Monsanto's HB-40 (partially hydrogenated terphenyl) as an extender plasticizer is a means of cutting costs while maintaining quality. HB-40, extremely low in cost, can be used to replace as much as 50% of the primary plasticizer, based on weight.

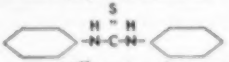
HB-40 is practically water-white for use in transparent or bright-colored products. It is low in toxicity, gives a dry "hand," increased tensile strength, has excellent electrical characteristics and high resistance to moisture. Mail the coupon for details.

Research Chemists' Corner

You may find something new here

Chemists who are looking for ways to improve products or develop new ones, may profit from studying the specifications of Monsanto's thiocarbanilide (diphenyl thiourea) given below. Research in the application of this product is far from exhausted. If you'd like to test thiocarbanilide for its possibilities in your projects, we'll be pleased to send you a sample without cost and without obligating you in any way. Just indicate your wishes on the coupon!

THIOCARBANILIDE (Diphenyl Thiourea)

Structure: 

Moisture:	0.5% maximum (test must avoid decomposing conditions)
Ash:	0.5% maximum
Specific Gravity:	1.32 at 25° C.
Solubility:	Soluble in alcohol. Insoluble in water and many other common solvents.

Two grades are available, one a white powder melting at 148° C. minimum and the other a white-to-grey powder melting at 146° C. minimum.

Reactions: A weak organic base. Boiling with hydrochloric acid results in formation of phenyl isothiocyanate. The sulfur can be removed by PbO in alcohol solution forming carbodiphenylimide or, in the presence of ammonia, diphenylguanidine. Condensation with CS_2 and sulfur under pressure produces 2-mercaptobenzothiazole.

Monsanto Santosite is milder, more economical in semichemical pulping

Santosite* (Monsanto's sodium sulfite anhydrous, technical) is a mild pulping agent for hardwood, mixed wood, flax, hemp, and many cellulose-bearing agricultural residues.

With hardwood of high lignin content and with mixed woods, Santosite delivers a good yield of pulp having relatively long fiber. Because of its mild action, Santosite does not destroy fiber in the process of delignification. Santosite solves the special problems that hamper ordinary methods of pulping hemp and flax. It pulps straw, corn stalks and other agricultural residues to make a variety of quality products.

Santosite is safe and easy to use because it is clean, non-toxic and non-irritating to workmen. Even in small quantities, Santosite is highly efficient. Less time is required for shutdowns to clean up beaters, screens, felts and other equipment. For further details on semichemical pulping with Santosite, mail the coupon or contact the nearest Monsanto Sales Office.

OTHER MONSANTO HEAVY CHEMICALS

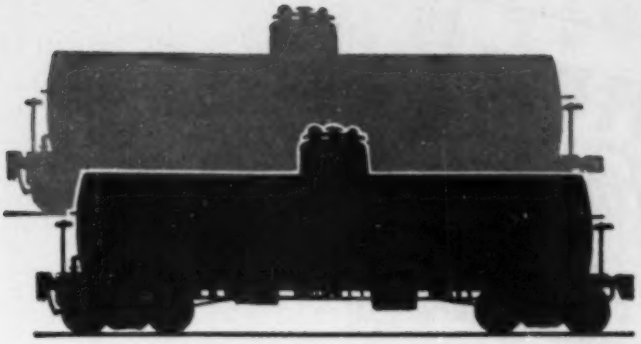
Basic Chrome Sulfate (Santotan*) for tanning industry
Salt Cake (Sodium Sulfate, Technical)
Sulfur Dioxide
Muriatic Acid
Nitric Acid
Sulfuric Acid
Chlorosulfonic Acid

Synergism brings higher detergency

In processes such as textile scouring, where high detergency is desirable, the synergistic action of Santomerse* No. 1 and tetrasodium pyrophosphate (TSPP) pays a bonus.

Synergism, or synergistic action, is the result of two chemicals working together to give detergency higher than the average of the two used separately . . . higher than either used alone.

If detergency is important to you, look into the possibilities of synergistic action of these two Monsanto products. For details, mail the coupon.



Liquid phthalic anhydride available in tank cars

Phthalic anhydride, usually reduced to dry flakes for handling, shipping and storage and changed back to liquid form for processing, is going directly to some Monsanto phthalic users in liquid form.

The liquid phthalic is slightly less expensive due to manufacturing economies. Further savings are effected by users because of reduced handling. Color and quality of the material are unaffected. There is some indication that the elimination of flaking results in a product of improved quality.

Monsanto, with more than 15 years' experience handling and storing liquid phthalic, offers technical information on liquid phthalic handling and storage to firms using this product in appropriate quantities.

At present Monsanto liquid phthalic anhydride is available generally only in tank-car quantities. Shipments are being made to some localities in tank-trucks.

Shoes can turn water but still "breathe"

Men who work outdoors, sportsmen and others who find it necessary to ignore the weather have the promise of good news in shoes. Monsanto's octadecyl isocyanate . . . $CH_3(CH_2)_{16}CH_2NCO$ . . . makes leather water-repellent yet leaves the pores open, so shoes can "breathe." Thus, shoes can afford protection against wet weather without sacrificing comfort.

This may be good business news for you. Octadecyl isocyanate also imparts similar quality to surface coatings, paper and textiles. Perhaps it fits into your production problem. It is a valuable intermediate in hydrophobizing processes. Because of Monsanto's expanded capacity, octadecyl isocyanate is in good supply.

Mail the coupon for a copy of Technical Bulletin No. P-125 which gives you complete details.

FOR YOUR LIBRARY

Timely Monsanto publications, listed below, will be sent to users of chemicals on request . . . free and without obligation. Indicate the items you want on the coupon.

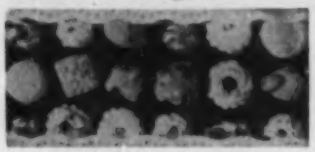
Monsanto Chlorine . . . 20 pages of information, including history, technical data, safe-handling suggestions.

Emulsifiers and Wetting Agents for herbicidal and insecticidal formulations. 12 pages of data on emulsifiers, wetters, solvents, formulations . . . procedures and equipment. (Technical Bulletin P-142.)

Handle Parathion Safely. Illustrated folder for safe handling of parathion by formulators, distributors and users.

Phosphoric Acid. 12 pages of technical data. (Technical Bulletin P-26.)

Aromatic Chemicals Improve Packages



Packages which carry candy, cookies, ice cream and other foods now give extra protection to their contents through the use of Monsanto Ethavan,* vanillin and coumarin. These aromatic Monsanto Chemicals "mask" undesirable odors and tastes which some products pick up from cardboard and paper pulp, allowing products to retain their appealing flavors and aromas.

Paper makers accomplish this "masking" by adding blends of Ethavan and coumarin, or vanillin and coumarin. The chemicals are dissolved in hot water and mixed into the pulp, or flowed on, depending upon the type of paper being produced.

Something to do about mildew

With the arrival of summer's hot, humid weather comes the problem of mildew . . . an expensive problem in many parts of the country. It's one which laundries can solve inexpensively by using Monsanto Biolite in the rinse water before acidic scouring rinse. For further information, mail the coupon.

*Reg. U. S. Pat. Off.

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☐ Phthalic, ☐ Maleic, ☐ Santosite, ☐ Thiocarbanilide, ☐ H_3PO_4, ☐ Ethavan, ☐ Coumarin, ☐ Penta, ☐ HB-40, ☐ Biolite, ☐ Santomerse No. 1, ☐ TSPP.

Send literature as indicated:
☐ Monsanto Chlorine, ☐ Emulsifiers and Wetters, ☐ Parathion Safety, ☐ Phosphoric Acid, ☐ Bulletin P-125, ☐ Bulletin P-32.

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BROWN FINTUBE *Thermo-Flo* PROCESS HEATERS

Newly designed unit shortens heating and cooling cycle... cutting equipment and processing costs

● Brown Fintube THERMO-FLO Process Heaters offer many advantages for process heating and cooling, and — including the cost of the *single shell* tank — usually *cost less* than a jacketed vessel of equivalent capacity.

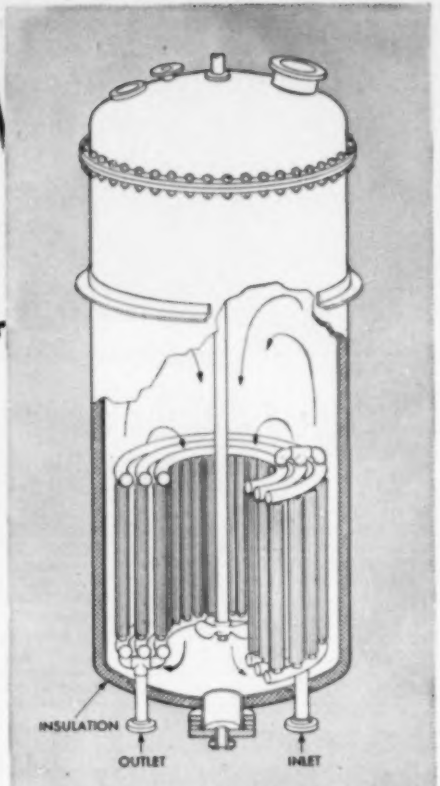
SHORTENS PROCESSING CYCLE — Use of Brown integrally bonded fintubes provides 4 to 10 times the heating surface of the same length of bare pipe coil, or many times the area offered by a jacketed kettle of equivalent size. This shortens the processing cycle, and permits more material to be handled in *smaller* and *less costly* vessels.

EFFICIENT HEAT TRANSFER — The material adjacent to the fintubes is heated quickly, and rises rapidly along the finned sections, forming a thermal siphon within the tank. This natural flow is sometimes augmented by the induced flow of an agitator, especially if quick mixing is desired.

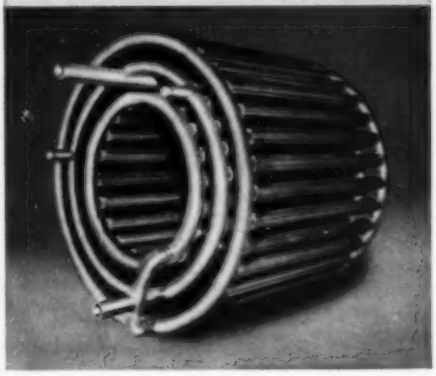
AVOIDS CRACKING AND COKING — The large heating area of the finned tubes permits processing with low temperature differential between the heat transfer surface and the material — minimizing damage to the material from localized overheating.

MEETS ANY REQUIREMENT — Brown THERMO-FLO Process Heaters are available with single or multiple circular banks — in any height and diameter to meet specific duties. Furnished in low carbon or stainless steel, or nickel, monel, everdur or other alloys — as single heaters or complete with tank — to meet individual conditions.

Price and delivery information furnished promptly. Write for Bulletin No. 492. It gives full details.



The installation diagram and heater coil illustrated herewith is only one of many applications, and types, of these heaters and coolers available.



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ELYRIA, OHIO

FINTUBE HEAT TRANSFER PRODUCTS

WHICH IS YOUR NEED...

WATER PURIFICATION
Through Distillation

- Potable Water from Sea or Brackish Water
- Pyrogen Free Water from any source
- Bacteriologically Sterile Water

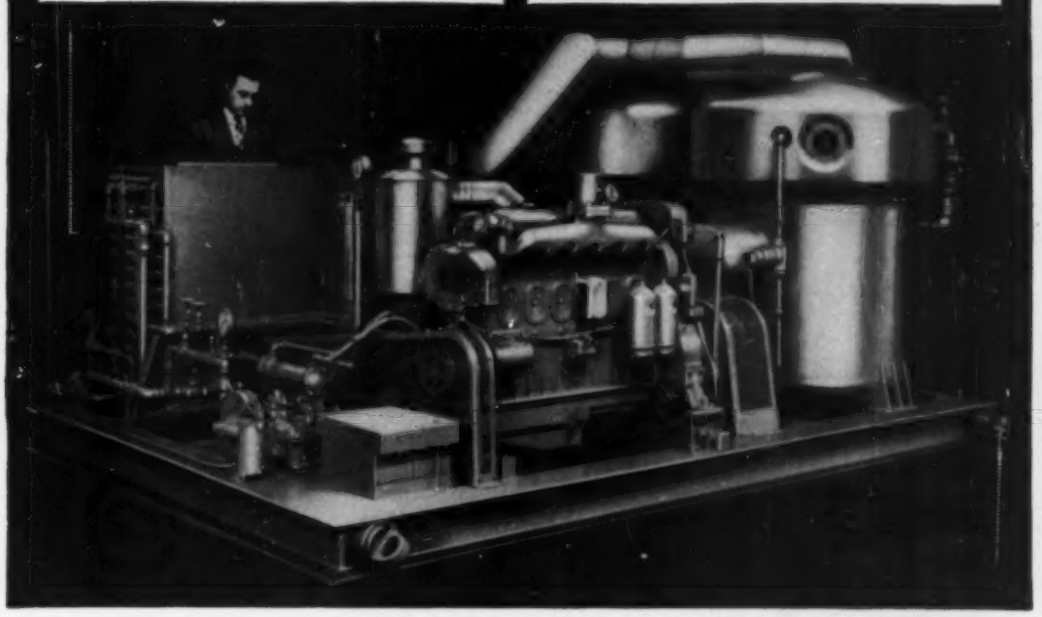
CONCENTRATION FOR RECOVERY OR DISPOSAL

- **Concentration for Recovery**

Tanning Liquors
Brine
Amino Acids
Other solutions and substances
Penicillin Slurry
Industrial Chemicals
Black Liquor from Pulp-Paper Mills

- **Concentration for Disposal**

Brine
Penicillin
Other solutions and substances



CLEAVER-BROOKS COMPRESSION STILLS are highly efficient in two widely divergent but essential applications in chemical and processing industries:

Chemically pure, pyrogen free, distilled water, (so pure that it is used for intravenous or medical preparations) can be produced by Cleaver-Brooks Compression Stills. Pure water at a cost as low as 65 KWH per 1000 gallons, (equal economies with Diesel units).

CLEAVER-BROOKS COMPRESSION STILLS solve many concentration problems. They provide economical recovery of valuable solids which are normally lost in waste disposal. Cleaver-Brooks Stills have concentrated Tanning Liquors, Brine, Penicillin Slurry, Black Liquors from pulp mills and many other solutions.

Available in standard size units from 75 gph to 2100 gph, electric or Diesel drive. Larger sizes to fit specific applications can be constructed for field erection. Your water or concentration problem will be thoroughly studied by Cleaver-Brooks engineers and recommendations made for improving your plant production.

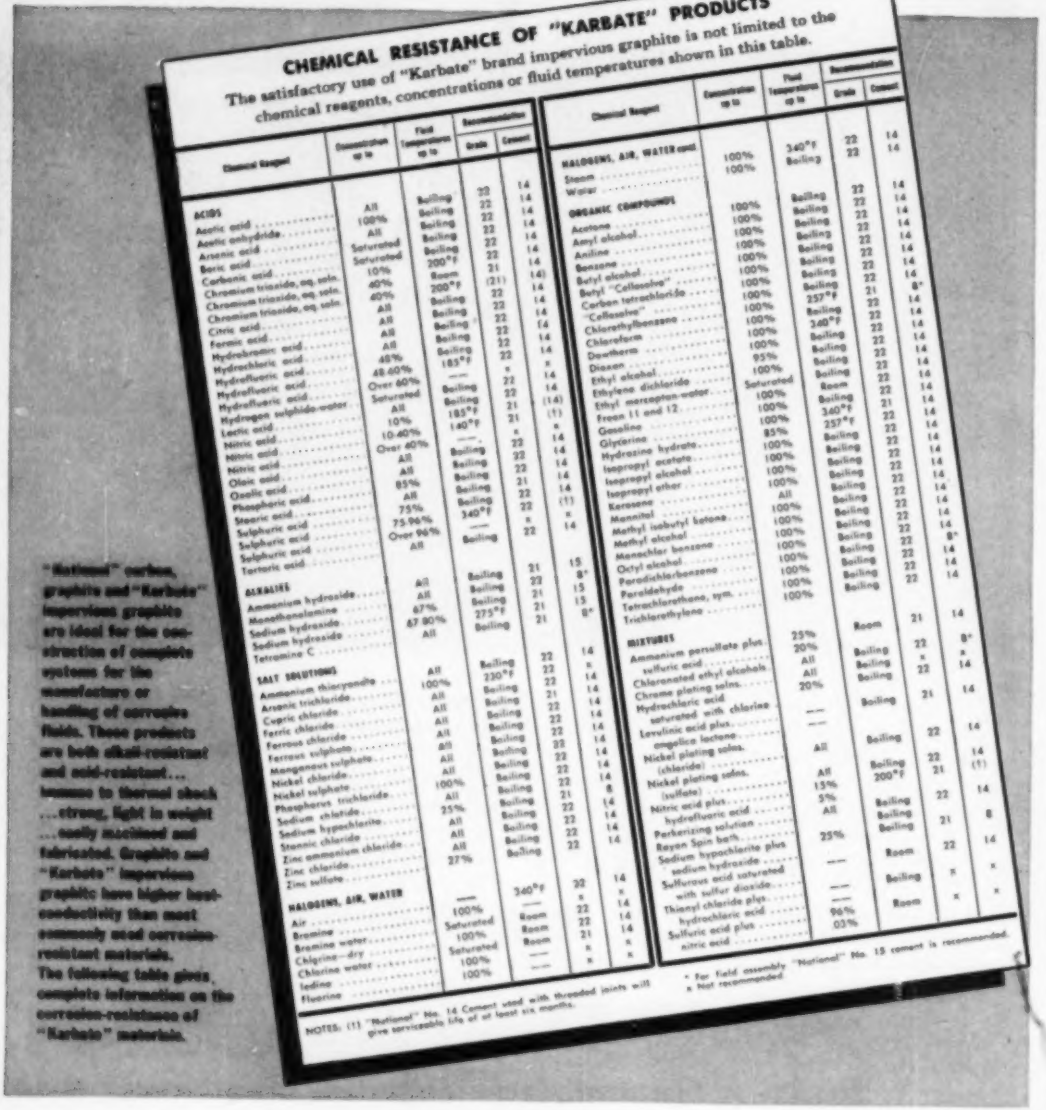
CLEAVER-BROOKS COMPANY
393 E. Keefe Avenue, Milwaukee 12, Wisconsin

For complete information on Cleaver-Brooks Distillation Units write on your letterhead to Dept. CDU.

Cleaver-Brooks

BUILDERS OF EQUIPMENT FOR THE GENERATION AND UTILIZATION OF HEAT

CORROSION



CHEMICAL RESISTANCE OF "KARBATE" PRODUCTS

The satisfactory use of "Karbate" brand impervious graphite is not limited to the chemical reagents, concentrations or fluid temperatures shown in this table.

Chemical Reagent	Concentration up to	Fluid Temperature up to	Recommendation: Grade	Recommendation: Cement
ACIDS				
Acetic acid	All	Boiling	22	14
Acetic anhydride	100%	Boiling	22	14
Arsenic acid	All	Boiling	22	14
Boric acid	Saturated	Boiling	22	14
Carbonic acid	Saturated	200°F	22	14
Chromium trioxide, aq. sols.	10%	Room	21	14
Chromium trioxide, aq. sols.	40%	200°F	(21)	14
Chromium trioxide, aq. sols.	40%	Boiling	22	14
Citric acid	All	Boiling	22	14
Formic acid	All	Boiling	22	14
Hydrobromic acid	All	Boiling	22	14
Hydrochloric acid	All	Boiling	22	14
Hydrofluoric acid	48%	183°F	22	14
Hydrofluoric acid	48-60%	—	x	14
Hydrofluoric acid	Over 60%	Boiling	22	14
Hydrofluoric acid	Saturated	Boiling	22	(14)
Hydrogen sulphide-water	All	185°F	21	(1)
Lactic acid	10%	140°F	21	x
Nitric acid	10-40%	—	x	14
Nitric acid	Over 40%	Boiling	22	14
Nitric acid	All	Boiling	22	14
Oleic acid	All	Boiling	22	14
Oxalic acid	85%	Boiling	21	14
Phosphoric acid	All	Boiling	22	(1)
Stearic acid	75%	340°F	22	x
Sulphuric acid	75-96%	—	x	14
Sulphuric acid	Over 96%	Boiling	22	x
Tartaric acid	All			
ALKALIES				
Ammonium hydroxide	All	Boiling	21	15
Monoethanolamine	All	Boiling	22	8*
Sodium hydroxide	67%	Boiling	21	15
Sodium hydroxide	67-80%	275°F	21	15
Tetramine C	All	Boiling	21	8*
SALT SOLUTIONS				
Ammonium thiocyanate	All	Boiling	22	14
Arsenic trichloride	100%	230°F	22	x
Cupric chloride	All	Boiling	22	14
Ferric chloride	All	Boiling	21	14
Ferrous chloride	All	Boiling	22	14
Ferrous sulphate	All	Boiling	22	14
Manganous sulphate	All	Boiling	22	14
Nickel chloride	All	Boiling	22	14
Nickel sulphate	100%	Boiling	22	14
Phosphorus trichloride	All	Boiling	21	8
Sodium chloride	25%	Boiling	22	14
Sodium hypochlorite	All	Boiling	22	14
Stannic chloride	All	Boiling	22	14
Zinc ammonium chloride	All	Boiling	22	14
Zinc chloride	27%	Boiling	22	14
Zinc sulfate				
HALOGENS, AIR, WATER				
Air	—	340°F	22	x
Bromine	100%	—	x	14
Bromine water	Saturated	Room	22	14
Chlorine—dry	100%	Room	22	14
Chlorine water	Saturated	—	21	x
Iodine	100%	—	x	x
Fluorine	100%	—	x	x
HALOGENS, AIR, WATER cont.				
Steam	100%	340°F	22	14
Water	100%	Boiling	22	14
ORGANIC COMPOUNDS				
Acetone	100%	Boiling	22	14
Amyl alcohol	100%	Boiling	22	14
Aniline	100%	Boiling	22	14
Benzene	100%	Boiling	22	14
Butyl alcohol	100%	Boiling	22	14
Butyl "Cellosolve"	100%	Boiling	22	14
Carbon tetrachloride	100%	257°F	21	8*
"Cellosolve"	100%	Boiling	22	14
Chlorethylbenzene	100%	340°F	22	14
Chloroform	100%	Boiling	22	14
Dowtherm	95%	Boiling	22	14
Dioxan	100%	Boiling	22	14
Ethyl alcohol	100%	Boiling	22	14
Ethylene dichloride	Saturated	Room	22	14
Ethyl mercaptan-water	100%	Boiling	21	14
Freon 11 and 12	100%	340°F	22	14
Gasoline	100%	257°F	22	14
Glycerine	85%	Boiling	22	14
Hydrazine hydrate	100%	Boiling	22	14
Isopropyl acetate	100%	Boiling	22	14
Isopropyl alcohol	100%	Boiling	22	14
Isopropyl ether	100%	Boiling	22	14
Kerosene	All	Boiling	22	14
Mannitol	100%	Boiling	22	14
Methyl isobutyl ketone	100%	Boiling	22	14
Methyl alcohol	100%	Boiling	22	8*
Monochlor benzene	100%	Boiling	22	14
Octyl alcohol	100%	Boiling	22	14
Paradichlorbenzene	100%	Boiling	22	14
Paraldehyde	100%	Boiling		
Tetrachlorethane, sym.	100%			
Trichlorethylene		Room	21	14
MIXTURES				
Ammonium persulfate plus sulfuric acid	25%	Boiling	22	8*
Chlorinated ethyl alcohols	20%	Boiling	x	x
Chrome plating solns.	All	Boiling	22	14
Hydrochloric acid saturated with chlorine	All	Boiling	21	14
Levulinic acid plus angelica lactone	20%	—		
Nickel plating solns. (chloride)	—	Boiling	22	14
Nickel plating solns. (sulfate)	All	Boiling	22	14
Nitric acid plus hydrofluoric acid	15%	200°F	21	(1)
Perkerizing solution	5%	Boiling	22	14
Rayon Spin bath	All	Boiling	21	8
Sodium hypochlorite plus sodium hydroxide	25%	Room	22	14
Sulfurous acid saturated with sulfur dioxide	—	Boiling	x	x
Thionyl chloride plus hydrochloric acid	—	Room	x	x
Sulfuric acid plus nitric acid	96% 03%			

NOTES. (1) "National" No. 14 Cement used with threaded joints will give serviceable life of at least six months.

* For field assembly "National" No. 15 cement is recommended.
x Not recommended

"National" carbon, graphite and "Karbate" impervious graphite are ideal for the construction of complete systems for the manufacture or handling of corrosive fluids. These products are both alkali-resistant and acid-resistant... immune to thermal shock ...strong, light in weight ...easily machined and fabricated. Graphite and "Karbate" impervious graphite have higher heat-conductivity than most commonly used corrosion-resistant materials. The following table gives complete information on the corrosion-resistance of "Karbate" materials.

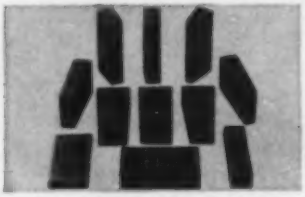
*and what to do about it_*

Install carbon, graphite and "Karbate" impervious graphite equipment for storage, conveying, and processing of corrosive fluids

HEAT EXCHANGERS—

"Karbate" impervious graphite heat exchanger types include: shell and tube, cascade, plate, bayonet and concentric. Available in standard sizes or tailored to your specifications. Provide excellent heat transfer. Resist acids and alkalis, immune to thermal shock, stand strain and vibration, light in weight, easy to install. Write for Catalog Section *M-8808-A*, describing Shell and Tube types; *M-8804* and *M-8809*, describing Plate type and Bayonet type; and *M-8807-C*, describing the Cascade type.

BRICK AND BLOCKS—



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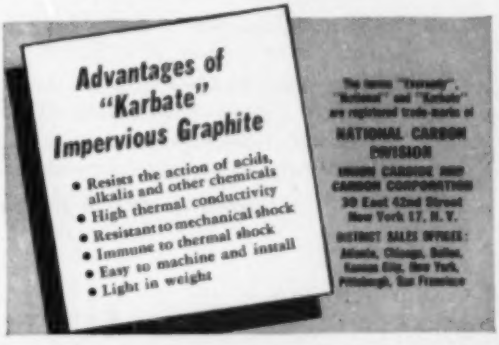

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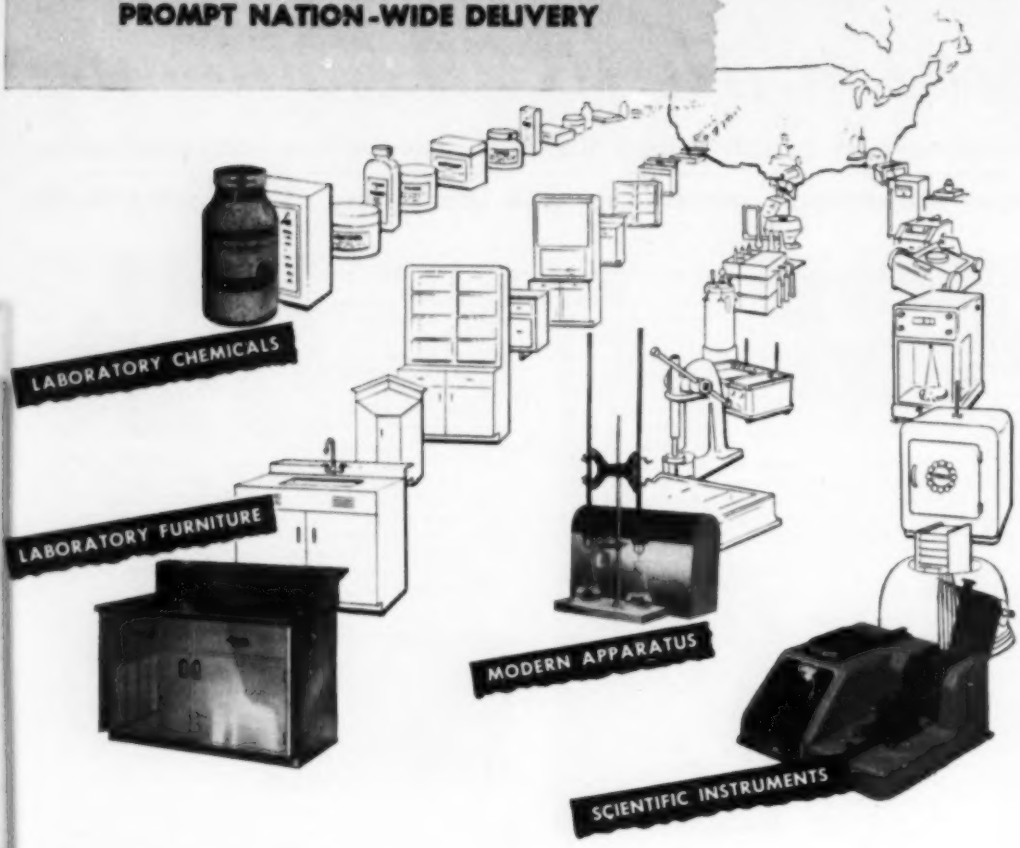

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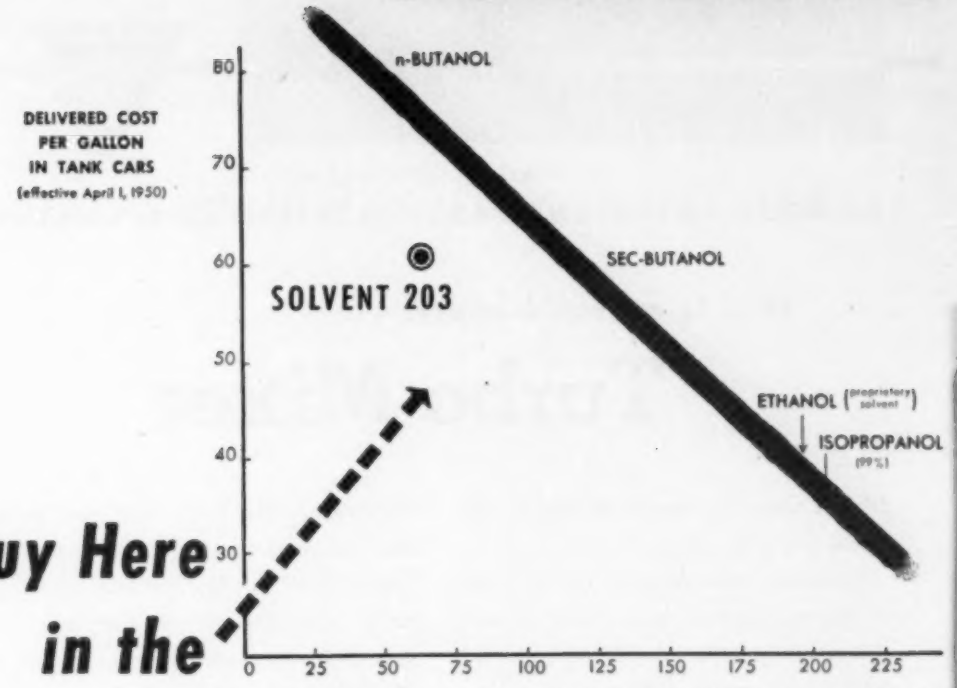

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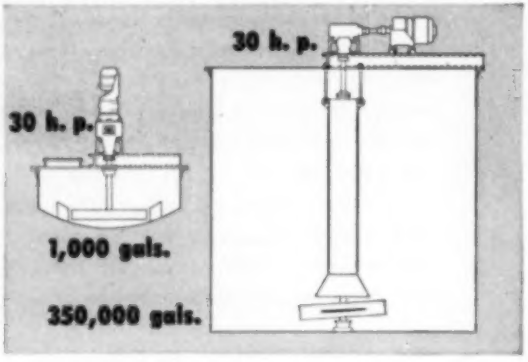

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OPINION AND COMMENT

THE ADMISSIONS COMMITTEE

ONE of the coproducts of our A.I.Ch.E. meetings is the opportunity to meet a wide variety of chemical engineers and to learn their views on Institute affairs. During the meeting at Houston in February, several of my conversations uncovered the fact that some members had no knowledge of how the business of the Admissions Committee was conducted or they had obtained entirely erroneous "scuttlebutt" information. Therefore, a thumbnail sketch of Admissions Committee operations seems to be in order.

The constitution states: "The Committee on Admissions shall be composed of at least fifteen active members of the Institute. Six members—shall constitute a quorum—." The present Committee consists of 21 members, of whom 10 are located in or near New York. In order to have complete files and information available the meetings must be held at or near the A.I.Ch.E. office. This means that in order to insure a quorum we must have a nucleus of members from the New York area who can attend practically every meeting.

It is important that this Committee be a representative cross section of the membership and in my opinion, the ideal committee would be composed of one member from each local section. Even so there are members from many areas, from Baltimore to San Francisco, and from Texas City to Buffalo. These men put out a real effort to attend meetings and are consulted by mail when questions arise in their area.

The Committee is representative in another respect, in that it includes men engaged in education, production, sales, research, development and design. Various types of industry, such as chemical, oil, rubber, plastics, and equipment are represented.

Monthly meetings are held in The Chemists Club and require from 5 to 9 hours depending on the number of applications. The Secretary's office has previously "processed" each application for Active and Associate—checked it for adequacy of information—obtained the References' statements particularly as to "years of experience" and "years in responsible charge." Each member of the Committee has previously been sent a copy of each application on the agenda but all References' replies are held in the Secretary's office and are only available to the Committee during the meeting.

Each application is scanned by the whole Committee, then one of the two Vice-Chairmen gives a summary statement of the replies received from the References. If the replies from the References have provided sufficient information, particularly as to the applicant's "duties," "experience," and "responsible charge," the application is then discussed and voted upon. If information is lacking, the Secretary's office or a Committee member is asked to obtain the information from the Applicant or his References or from someone in the Local Section who is informed on that particular situation.

All approved applications are now published in *Chemical Engineering Progress* and if uncontested, the Admissions Committee then recommends the qualified applicants to Council for election.

Applications for Junior and Student membership are reviewed by a subcommittee composed of at least the Executive Secretary and the Chairman of the Admissions Committee, followed by appropriate recommendations to the full Committee. So much for the operating procedure.

You can be assured that a Committee with such a diversified membership is genuinely interested in seeing that all qualified chemical engineers are members of A.I.Ch.E. regardless of occupation or industry. Its most difficult task is to interpret the broad wording of the Constitution into the specific qualifications of each application. Committee members from each section of the country bring in the views of their section. We frequently consult with Council, asking for its interpretation of some specific question. The consensus should reflect the views of the majority of A.I.Ch.E. members and the Committee is guided accordingly.

All of you reading this page—members and nonmembers—can aid the Institute and its Admissions Committee, if when asked to serve as a Reference, you will give specific replies to the questions regarding "duties," "years of experience in chemical enginering," and most important of all, "years in responsible charge," now defined as "individual professional responsibility for important work in chemical engineering." When you fail to answer these questions, it not only delays action on the application while the Committee secures the information, but it also jeopardizes the ambition of your friend or associate to become a member.

The Admissions Committee is now and has been for many years a "working" type of committee. It is set up to process applications promptly as received. The members are seriously interested in bringing into the American Institute of Chemical Engineers all those who are qualified and have the desire to participate in this professional organization.

R. P. Kite

What lining for greatest protection? Lowest cost?

On your next lined-tank installation — put it up to Stoneware. Send us your sketches or prints, tell us what solutions you plan to use, their concentration, what impurities are developed, operating temperatures and margin of safety required. In turn we'll suggest materials that will prove most effective, for the longest period of time, at the lowest cost.

"U. S." Engineers are not wedded to any one material. Whether we recommend our Tygon plastic sheeting linings, Tygoflex dip lining, Paraply rubber linings, USSCO acid Brick or Tile, Resilon asphaltic resinous linings, Republic sheet or homogeneously bonded lead linings, phenolic or Duralon hard coatings, the suggestion is made with one question in mind:

What tank lining will handle your solution the most effectively, for the longest time, at the lowest cost?

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U. S. STONEWARE

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. . . Time was when a licensed engineer was something of an anomaly . . . here is the opinion of these speakers from a symposium given at the annual meeting we find out that Licensing is no longer a theory . . . it is no longer a debate for engineers that the newly graduated engineer should apply for a license as soon as he can . . . the older engineer should find out what he needs to do to obtain a license . . . and that courts accept the testimony of licensed engineers only. . . .

ENGINEERING LICENSING

PRESENT STATUS AND FUTURE OUTLOOK

LICENSING—VIEWPOINT AND OUTLOOK

JOHN M. WEISS

Chemical Engineer Consultant, New York, New York

ENGINEERING licensing has gone far beyond a theory. Every state and every territory, have laws governing the practice of engineering, and in all but one or two cases, chemical engineers are included in the scope of these laws. Licensing is here to stay, and the constructive thing is to consider what positive steps appear of value in extracting the greatest amount of benefit from the situation.

The purpose, therefore, of this round table is to appraise the situation and to consider if there is anything that the chemical engineer might do to obtain the greatest benefit from the laws.

In our recent poll of the Institute membership, we received about 1500 replies, about 20 per cent of the membership. Results can be given only as representative of these replies, since partial returns may not give a true picture. It is interesting to note, however, that the first 500 replies received did not vary, on a percentage basis, more than three-tenths of one per cent from the results of the entire poll. The two samples were at least consistent with each other. The figures were these:

Of Active members, 612 replies, of whom 351 or about 58.2 per cent were licensed.

Of Associates, 68 replies, of whom 51½ per cent were licensed.

JOHN M. WEISS, consulting chemical engineer, graduated from the University of Pennsylvania in 1905. Until 1922 he occupied various positions with the Barrett Co., finally director of development. He was president of Weiss and Downs, Inc., from 1922-43. Since that time he has been managing partner of John M. Weiss and Co., at 50 East 41st St., New York, N. Y.

Of Juniors, there were 824 replies, of whom 29 per cent were licensed.

The two states returning the largest number of cards from Active members were New York, with 53½ per cent licensed, and Pennsylvania, with 71 per cent licensed. This indicates that where laws have been enacted rather recently, as in Pennsylvania, the tendency is for the engineer to license before examinations become mandatory.

Junior Members Licensed

The large number of Junior members who were licensed was surprising. Twenty-nine per cent for the younger men was a high figure. Of those who were not licensed, namely, 577, 246 said they were qualified for license, and 331 were not yet qualified. Of those 577, 53 per cent intend to license. The remainder is about equally divided between those who do not intend to license and the undecided ones.

In general those who thought themselves qualified mainly did not intend to license or were undecided, while those not yet qualified mostly intended to license, with a small percentage of undecided.

It was also surprising to note that of the entire group of unlicensed Junior members, only 28 had registered as engineers in training, indicating that this procedure, for some reason, is not attractive to our younger men.

The poll seems to indicate that the trend is toward about 60 per cent of the membership of the Institute to be licensed when they are eligible. The remainder does not believe it necessary or desirable for them to do so. This appears reasonable, because many engineers are employed by corporations where licensing is not a requisite for the work they do.

In New York State, where laws licensing engineers have been in existence for 20 years there have been no revolutionary changes, except a somewhat better recognition of the professional status of the engineer. Civil service positions involving engineering practice in the state and its subdivisions are now filled only by registered engineers, in accordance with specific legislation. Important planning committees usually include "registered engineers" where engineering is important, such as in highways, bridges, and similar public improvements.

The unauthorized use of the term, "engineer," in publicity has been almost eliminated. In one year 105 listings in the telephone book were eliminated in the case of unregistered individuals, and 217 similar violators in advertising and the like were corrected without the necessity of court action.

The New York civil courts have adopted the general policy that expert engineering testimony will not be received from unregistered individuals. They have further taken the stand that an unregistered engineer cannot recover fees for engineering services and such cases are dismissed without trial.

A recent case involved a mail-order house which was advertising free engineering services in connection with the sale of heating equipment. The matter did not reach the courts, since the company agreed to discontinue such advertising when the legal situation was brought to its attention. In this connection, the new provision in the law of New York for procedure by injunction against violators has proven to be a most effective deterrent.

From the standpoint of the consultant, there have been two important developments, one local and the other national. New York State has an income tax law which applies both to corporations and to individuals. To cover business which is not incorporated the state has a nonincorporated business tax, which is a substantial amount. Professional service, however, is exempt from this tax and the professional is taxed only once, instead of twice by the state. The Income Tax Bureau has taken the position that registration of the engineer is prima facie evidence that he is professional and no attempt is made to assess this tax.

In contradistinction, the consulting chemist who is not a chemical engineer, is held to be nonprofessional unless he submits convincing evidence to the contrary. And this, where the work has been largely that of a testing laboratory, has not been possible to prove in many cases.

A similar question—this time on the national scale—is raised by the extension of the Social Security Act to self-employed persons. The Act specifically exempts professional persons in specific terms, such as lawyers, doctors, chemical engineers, etc. The chemist is not mentioned in the law and it is understood that the lawmakers agreed that only registered professions could actually be considered professional.

Engineering Compared with Law, Medicine

We seem to be making slow but steady progress for the recognition of engineering on a basis comparable to that of law and medicine. Admittedly the advantages appear to accrue primarily to the self-employed independents, and there is only one concrete result which can be adduced to the direct benefit of that large body of engineers employed by others. Under the Taft-Hartley Act professional employees are given the right to determine whether they desire to be organized, and if so, to form an organization entirely restricted to professional men, so that they cannot be forced into labor unions dominated by nonprofessional workers. Registration has proved a useful tool in establishing professional status in certain plants where the question arose. Other than this, the benefits to employed engineers are indirect, and since the labor union question has not risen in many cases it seems explainable why a large number of the employed chemical engineers does not register.

On the employers' side, however, they are in some cases giving considerable weight in their employment of individual engineers, to the possession of a license. They are also encouraging their older men to register, being mindful of their own legal responsibilities in case of mishaps with resulting charges of negligence. It has been held that if an engineering design is faulty and a fatal accident occurs, a nonregistered man responsible for the design can be held guilty of manslaughter, while if registered he is guilty only of a professional error of judgment. The same question of type of liability may extend to an employer who employs unregistered men to do engineering work, but this question has not yet been settled by any specific case. The advantages to the employer, if he requires court testimony at any time, of having his engineers licensed is of course obvious.

"PE" Like "MD"

Finally, the Bureau of Motor Vehicles of New York is now issuing special plates to registered professional engineers with the letters, "PE," preceding the number. This is analogous to the "MD" plates which have been issued to doctors for many years.

Various manifestations of professional registration are admittedly small. But the results are cumulative and I think are destined to increase in the future, if the engineering profession attempts to take full advantage of the situation.

Subsequent to compiling these data I, as a representative of A.I.Ch.E. on the National Council of State Boards of Engineering Examiners, have culled further information which will prove useful in a study of the general picture.

As of June, 1949, the number of registered engineers in the U. S. stood at 153,277, about 25,000 more than the previous year. Since 1945 the curve has tended sharply upward.

The 1949 proceedings contained also some definitions of criteria for the boards to use in appraising the types of experience presented. This is different for the various branches of engineering. The one for chemical engineering reads as follows:

Professional Experience

Design, Specifications and/or Construction: Equipment for chemical enterprises; processing plants; plant layouts; equipment; economic balances; production planning; pilot plants; heat transmission apparatus.

Development: Processes, pilot plants; refrigeration systems for food processing.

Research: Laboratory; pilot plants; director; markets; unit operations; kinetics; processes; calculation and correlation of physical properties.

Responible charge of broader fields of chemical engineering; executive.

Consultation: appraisals; evaluations; reports; economics; chemical patent laws.

Operation of pilot plants; product testing; technical service; technical sales.

Teaching, full time, at college level. Editing and writing.

Sub-Professional Experience

Construction: Process equipment; pilot plants; piping systems.

Operation: Shift operator; special chem-

icals manufacture (solutions); pilot plants; trouble shooting; glass blower.

Drafting: Flow sheet layout.

Instrument making and servicing; routing analyses; routine sampling and tests; lathesman.

Analyst: Routine, under direction. Laboratory assistant (commercial, college); computations, under direction; data taking.

Sales: Routine, of standard equipment.

Finally the proceedings contain a list of the membership of all the State Boards of Engineering Registration and information regarding the requirements in each state for "registration by endorsement," that is, without examination, and can be referred to in this connection by our membership.

REGISTRATION OF ENGINEERS

T. KEITH LEGARÉ

Ex. Sec'y. Nat. Council of State Boards of Engineering Examiners, Columbia, South Carolina

I WOULD like to report on the present status of registration:

As of June, 1949, the total number of registrants in good standing was as follows: professional engineers, 153,277; land surveyors, not engineers, 9,123; total, 162,400. More than 2000 engineers are registered in a number of states, therefore there is a duplication of registrants reported from the states, especially in Illinois, where some structural engineers are registered also as professional engineers. It is estimated that there are more than 150,000 registered professional engineers in good standing in the United States. The number of engineers-in-training that has been certified is 11,524.

Sixteen states have amended their registration laws during the past two years, principally to provide for the certification of engineers-in-training, but in some cases, to make their law conform to the Model Law and raise the standards of requirements.

The District of Columbia does not have a registration law yet. It has a comprehensive law that has been carefully drafted and worked on for several years, which has been referred to the District of Columbia Committee.

The "engineers-in-training" program has been a wonderful success in my own state (South Carolina). Ninety per cent of the engineering students who have finished in the last year or two have taken engineer-in-training examinations and have become certified.

It means that young engineers moving from one state to another can get credit for this examination that was given immediately after they finished college. We give these examinations on the campus, which makes it convenient for the young men. I will give you one example.

Campus Examinations Advantageous

Two boys from Puerto Rico finished at the Citadel last summer. They took their engineer-in-training examination, and were given certificates as engineers-in-training. They went home to Puerto Rico and there was a large job there that they wanted to work on. For some reason one of the regulations was they had to be registered engineers or had to be certified by the licensing board of Puerto Rico. The Puerto Rico board agreed to recognize the examination given them as engineers-in-training, and certified them.

T. KEITH LEGARÉ has been executive secretary of the National Council of State Boards of Engineering Examiners more than 26 years; secretary and member of the South Carolina State Board of Engineering Examiners 28 years; for many years chairman or member of the committee on registration, ASCE. He was chairman of conferences that drafted and amended the Model Law.

As I said, the advantage is that young engineers moving from one state to another get credit for the examination. Later on, after they have acquired the requisite years of experience, they don't have to be examined in the subjects they had in college—by which time they may have forgotten a great deal.

Requirements for registration are rather hard to describe, because there are differences in the 51 laws, due to the time that the law was passed (some are 40 years old), and also due to local conditions.

But the Model Law, which has been followed by more than a majority of the states, has the following standard requirements. There are three alternates.

A—The first one is graduation in an approved engineering curriculum plus four years or more of experience in engineering work of a satisfactory character.

B—If the man is not a college graduate, eight years or more of engineering work of a satisfactory character plus a written examination. The written examination is to show that the man has acquired his education in some other way than in college.

C—Twelve years or more of lawful practice in engineering work of a satisfactory character indicating that the applicant is competent to practice engineering, and provided the applicant is not younger than 35 years. This requirement is for the man of long-established practice. Many states now require all applicants to pass a written examination except those of recognized standing and long experience.

Written examinations vary in the different states. Most of them though generally consist of two parts: *Part 1*, based on problems pertaining to fundamental engineering subjects; and *Part 2*, based on problems pertaining to professional practice or the application of engineering knowledge. In some cases *Part 2* is limited to a particular branch of engineering.

Oral examinations are given by some boards to test doubtful cases, especially when the experience record is not satisfactory and not considered conclusive evidence of competency.

In South Carolina, if a graduate of an accredited engineering curriculum, who has had an experience of four years, but not of a high type, and we are not satisfied that he is competent to be

licensed; we ask him to come before the board for an interview and to bring exhibits of his work. We can find out a lot from a man that way in a few minutes; generally we don't spend more than 20 minutes with him. They are the ones who are not given the written examination.

Reciprocal Registration

The problem of interstate registration or registration by endorsement, or reciprocal registration, as it is variously called, has been one of the most difficult in the registration program, and has caused much misunderstanding. A few of the state boards have been inclined to overemphasize legal restrictions. The National Council has been continually working on this problem and considerable progress has been made.

In the National Bureau of Engineering Registration, we have an Advisory Board of representatives from the national engineering societies and Dr. John M. Weiss represents the chemical engineers. It was established to minimize the effort and expense of registered engineers desiring to secure registration or license in more than one state, and to assist the state boards in securing verified information regarding the professional records of applicants. It has rendered valuable service to a number of registered engineers and boards.

However, there are still a few state boards which decline to utilize this service. Some states can't use the Registration Bureau certificates because their legal advisers have told them they can't. That is the situation in Pennsylvania.

For those interested in registration, the National Council of State Boards of Engineering Examiners publishes three little pamphlets. One gives the addresses of all the state boards and other general information, one is about the National Bureau of Engineering Registration, and the other about the requirements for interstate registration. If you write we will be glad to send them to you.

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

J. F. FAIRMAN

Vice-President, Consolidated Edison Company of New York, Inc., New York

I WOULD like to introduce my remarks with a brief statement of how I happened to get interested in licensing. The two principal jobs of my career have been in teaching and in the public utility business. Both these occupations in most cases, if not in all of them, are exempt from the requirement of licensing.

It happened to fall to my lot when I was a cub instructor, to be assigned the job of writing examination questions for some poor devils who were going to take the examination in the State of Michigan. I was supposed to write some questions in the field of electrical engineering. I felt that that was grossly unfair to the victims. Here was I, not very long out of school myself, trying to impart a certain amount of knowledge to juniors and seniors in electrical engineering, not being too sure of the subject and being only a couple of jumps ahead of the boys most of the time, pretending to write examination questions for some poor devils who were trying to get licenses to practice professional engineering. I didn't remonstrate too much, however, because when the boss gives you a job you do it. I did it, with as much charity as I could command, and I had to correct the papers, too, and again I invoked sweet charity.

JAMES F. FAIRMAN is a vice-president of Consolidated Edison Company of New York, Inc., in charge of production and operation. He has been active in several engineering societies—has served on ECPD; president of the New York State Society of Professional Engineers; vice-president of NSPE, and currently president of AIEE.

But I inquired of the head of my department, "Do we have a licensing law here" And when he said we did, I said, "I never heard about it as a student; isn't it something that I should pay attention to? Shouldn't I try to get my license, so I would be better qualified to write questions for others to answer?"

Certification and $25

He said, "You can if you want to. But as employees of the State of Michigan, we are exempt, and I wouldn't bother if I were you. And besides, it costs you $25." Well, $25 is $250 to an instructor—I guess it still is—so I let time pass and forgot all about it.

I went to New York and became connected with the Brooklyn Edison Co., and one of the first things I saw on the wall of the boss' office was one of these nicely framed diplomas certifying that the Regents of the State of New York recognized that Joe Doakes is competent to practice professional engineering. And I said, "Oh, you have that licensing law down here. Do you have to be licensed?"

He said, "No, we don't have to be licensed, because we are under the jurisdiction of the Public Service Commission of the State of New York and any business under the jurisdiction of a state agency automatically exempts that business from licensing."

I said, "I see you have one. Why did you get one?"

He said, "Well, I was practising when the law was passed and got it under the grandfather clause; that was the way."

I said, "Maybe it's good insurance, maybe I should get one."

And he said, "Well, you might, we will certify to your competency." But he brought up the 25 bucks again. And I didn't think too much about it.

Some years passed and I was being prepared to be an expert in a case where the heat was on us and we had to prove that we were innocent. I lined up the testimony to the satisfaction of counsel, and one day he said, "Now give me a

little biographical sketch of your education and experience."

I did—that was easy. He said, "You forgot to put in that you are licensed."

I said, "But I'm not licensed."

He threw up his hands.

I said, "You know in the State of New York I don't have to be."

And he said, "That may be true. But all the opposing counsel has to do is ask that one question. And maybe I can't even keep the testimony in. And you are our best witness."

Well, we got by. But that stirred me up to the fact that perhaps a time would come when I couldn't be used as an expert witness; a time would come when it might keep from me a plum that might be hanging on the tree. So I got busy and proceeded to get the license. Then I looked around to see who was doing something about this matter of licensing; who in the engineering societies. The Institute of Electrical Engineers that I belonged to was inactive. I found and joined the New York State Society of Professional Engineers.

I began to stick my neck out and ask questions. And I got some jobs—one leads to another. And here I am, explaining the National Society of Professional Engineers, which has a place in the scheme of things. It came into being primarily as a group of men who, having been licensed, wanted something constructive done about licensing on a national basis.

At the present time it is an organization of some 21,000 licensed men, most of whom hold their membership through membership in one of the state societies. We have 34 state societies now. It was organized in 1934 because the engineering profession found that it had at that time nothing that would be recognized in Washington or any place else, for that matter, as a voice representing the profession. Four societies in the East, four state societies which had been organized for the purpose of chaperoning the licensing law and other purposes in the respective states of Connecticut, New Jersey, New York, and Pennsylvania, joined together and formed the National Society of Professional Engineers. In 15 years it has grown from four state societies and 3400 members, to our present status, a very rapid growth—probably the most rapid growth of any organization of engineers which has ever taken place.

It is organized along geographic and political lines—each of the component units, starting at the bottom, the local chapter or county chapter, as it usually is, consisting of a county, although where counties are rather thin it may embrace two or three adjacent counties, then the state society, and the national society; each of those respective units of organization is responsible for doing the job within its own sphere. It is responsible to the individual member at each level, who has a direct voice in electing the officers and helping to establish the policies and program of the organization.

State societies are not merely federated in the National Society, although the National Society consists of all members of all the state societies, nor is the state society simply a federation of chapters. At each level the individual member is an individual member, of local units, state units, and his national unit, and expresses himself directly by vote and attending meetings, either himself or through his representatives, to take part in the deliberations.

Public Welfare NSPE Concern

NSPE isn't concerned at all with technology. It believes those fields are taken care of adequately by the other societies. It is in no sense competitive in the field of our specialized technical interests, it has nothing to do with them. It is concerned solely with the problems that we believe are common to all engineers, regardless of our particular type of specialization, in the economic, social and political fields. Its stated objectives in the constitution are the advancement of the public welfare and the promotion of the economic, social and political interests of professional engineers.

The NSPE legislative committee and its counterparts in the several state societies analyze proposed legislation to see if it promotes the welfare of the engineering profession; a legislative analyst is employed in the national headquarters in Washington, and he edits and gets out a Legislative Bulletin which is issued periodically to keep the members informed on latest developments and progress on legislation at the national level. He also, if he can get the information from the states, incorporates in it as a vehicle of information to all the states, tendencies and legislative measures which are introduced or proposed, or have passed, and information on the effectiveness of their administration as developed by particular incidents which may be negotiated or tried in the courts. He broadcasts to the members.

At the regular meetings, both of the National Society and the state society and of the county chapter, the chapters and the state societies and the National Society consider matters of legislation proposed at the various levels, and determine what steps to take either to support or oppose.

Then we have the engineer in his role in connection with national defense. The recent war of course demonstrated, as we all know, that national defense requires large numbers of competent engineers. And it requires that they be utilized properly if our defense efforts are to be most successful.

And there are questions on the ways and means of procuring the services of engineers for certain emergency assignments. And of course, in addition to their use in war, there is the continual use of engineers in the various national bureaus in peacetime. Policies of the defense establishment pertaining to engineers are clearly of greatest concern to members of the engineering profession.

We have a committee known as the Military Affairs Committee, which makes a continuing study of the problem, assists in the development of appropriate legislation, in order to utilize to best advantage the engineers' contributions to national defense, both in war and in peace.

Now, of course, we are building for the future. Our profession will be only as good as the engineers of the future. For this reason it has been and will be a fundamental aim of NSPE to assist our engineering schools in the maintenance of the highest possible standards of education, and in this we cooperate with the American Society for Engineering Education, and with Engineers Council for Professional Development; the latter is the principal accrediting agency of engineering curricula satisfactory to the various state boards of examiners.

Recently we have laid considerable emphasis on the fact, and the educators are with us, that the development of a conscious professional approach in the mind of the student is of great importance. And recognizing the many problems that face the young engineer and the importance of these men to the future of our profession, we have established a special committee on the problems of the young engineer, whose objective is the strengthening of the faith of the young engineer in the profession as he goes through the hard school of experience. The committee is paying special attention to those starting as employees of large industrial concerns. It is working with industry to obtain recognition of the professional status of these young men.

Under our state registration laws graduation from an accredited engineering school is not sufficient to qualify a person for registration; he must undergo a period of practical experience. NSPE believes these men should have legal recognition and be associated with the professional movement during their

formative years. So we have recommended to the state societies that they press for enactment of engineer-in-training provisions in the state laws, where they do not already exist, which would give the young graduate some recognition under the law, and enable him to take the academic phase of his examination while the subjects are still fresh in his mind. We have urged further that our state societies accept registered engineers-in-training as associate or affiliated members.

Every state or territory of the United States, with the exception of the District of Columbia, has a registration law. As registered men, we believe these laws are for the benefit of the public, and since these laws are designed for the welfare and safety of the public, NSPE is unqualifiedly pledged to their support. We cooperate with state boards of examiners, and urge societies to seek amendments to improve their laws. NSPE will urge all qualified engineers to become registered under their state laws, thereby giving legal recognition to the profession and insuring the public competent engineering service.

We subscribe to the principle that a professional engineer is entitled to adequate compensation for his services, whether he is a consultant, an industrial manager, or an employee. By cooperating on such studies as the *Engineering Profession in Transition*, NSPE helps to get the facts needed for improvement of the economic status of the entire profession, and to provide the basis for adequate fees and salaries which may be suggested by the member state societies for use in their territories.

Men shouldn't be admitted to the learned professions who have not a proper concept of right, justice and ethics. The courts have so spoken, and the public is entitled to adherence to this fundamental philosophy. NSPE, instead of adopting its own code of ethics, as most societies have done—which is funny, because they all say the same thing, and it is just a matter of how many commas and where you put the verses—adopts the canons of ethics as propounded by ECPD, and is working with our states and chapters for complete adherence to these canons and the improvement of the canons in the light of experience.

In our press releases on matters of public interest concerning the engineering profession, in the proclamation of "Engineering Weeks" by several state governors, in testimony before legislative and executive bodies, NSPE is guided by the professional nature of its members and seeks to convey that concept to the public mind. But it is what the individual professional engineer does and says that is of the greatest weight and effect.

It is for this reason that primary emphasis is placed on keeping him informed of matters of common interest and professional development, through our magazine, *The American Engineer*, and our *Legislative Bulletin*, and the publications issued by the several state societies and circulated among their members. The public relations committee is continuously developing aggressive public relation programs to inform the public of the contribution of the engineering profession to the national welfare.

NSPE also thinks of itself as a possible vehicle for accomplishing this much-talked-about, much-sought-after but long-neglected unity of the engineering profession. Of course, whether that succeeds or not will depend on how many of these 150,000 registered engineers join in this movement and give it their support.

IMPACT OF LEGISLATION ON JUNIOR ENGINEER

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I DISAGREE with the idea that the profession has been pretty well sold on professional engineer. I was impressed some time ago to read the statement, "the greatest shock to the human mind is the impact of a new idea."

My thesis is that this new idea, comparatively, is the idea of professional licensing of engineers. The impact of the shock has been on the systems of our older engineers, corporations employing engineers, engineering colleges, and some national engineering societies.

One of the troubles has been the seeming unwillingness of college professors and college engineering schools to inform their young engineers of the seriousness of the profession, and to ask them to become engineers-in-training. This is not strange when you contrast the engineering profession with the older professions of law and medicine, and yet you would hardly hire a doctor who was not a licensed practitioner; neither would you engage a lawyer who had not passed the bar examination.

Someone said that not all engineers needed licensing. Of course that leads to a question, who and what is an engineer?

When I went to school I was told that an engineer is one who uses the forces and products of nature for the benefit of mankind. A year or two ago in a court case in Chicago a man hoping to qualify on the witness stand as an engineer gave that definition of an engineer, and the cute lawyer said, "My, my, the scrub woman in my office does that every morning, is she an engineer?"

Nonsense, gentlemen. The laws of 48 states and all the provinces of Canada tell us who is an engineer. He is one legally qualified to practice his profession. A recent case in a Pennsylvania court concerns a young man, a graduate of one of our accredited technical schools, who having performed engineering work attempted to collect his fee. The court ruled, that a man claiming to be an engineer and per se not registered in the state, could not collect for his services as a professional engineer.

I actually had this experience in a case several years ago in this state. The opposing engineer on the other side gave some damaging and unusual testimony. There was no doubt about his qualifications in my mind. But our lawyer, when he came up for cross-questioning, said, "You are an engineer?"

The answer was, "Yes, sir, of 34 years' experience."

"You are then a licensed professional engineer in the State of Pennsylvania?"

"Well, no; I'm not."

The lawyer said, "You are not?" He turned to the judge and said, "I don't care to cross-question this witness." His

entire testimony in my belief went by the board.

There's one other reason why, in my mind, whether you are a chemical engineer or an electrical engineer or a mechanical engineer, we must all act together. Eighty per cent of all engineers are profoundly concerned with the Taft-Hartley Act. The Taft-Hartley Act affords protection to the professional engineer, as providing individual intellectual and creative effort and talent. The Wagner Act made no distinction between professional and nonprofessional employees. Our technical societies have appeared to me hardly to realize this state of things.

There are certain unions who have claimed at most every hearing in Washington for the past ten years to represent, not the mechanics, but the graduate and professional engineers. Rot, you say, but not to the nonengineering Congressman.

I like what Charles Wilson, president of General Electric, said to the engineers. He said, "In your preoccupation with the slide rule you cannot leave to others, to economists, to politicians, and to lobbyists, the large job of defending the way of life that has been made possible by the contribution of the engineer."

Licensing in Pennsylvania

Let me give the background of licensing in Pennsylvania. The first law governing engineering licensing was passed in this state in 1924. When I learned about it I was quite mad, because it was taking something away from me. Soon I got a letter from a prominent engineer asking me to take part in a conference by which we could fight such an insidious thing. I went. And as a result, a considerable sum of money was raised by prominent engineers in this state to fight the law. And we were successful, we had it declared unconstitutional. And we said, 'now, we have buried this thing.'

But no more had we gone home, than out of somewhere came a great movement, not through consulting with some of us who felt we were leaders in the profession, but a movement out of somewhere that put together and put through in this state in 1927 a new and model law which has stood the test in court.

I became interested. I found that the men who backed the movement were the rank and file of the profession. Largely, they were civil engineers; they were state, city and county employees. But

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they felt it necessary under the laws of that time.

Some states today have what I consider weak laws. Many states have nearly identical and model laws. Every province in Canada today has an excellent registration law, and should any of you men decide to do work in Canada I advise you to learn all about it. The Canadian technical societies are joining wholeheartedly in the movement there, and in my estimation they are at least ten to twenty years ahead of us in the professional engineering movement.

If you who are practicing engineers would take an interest in the state and in the making of better state laws, it would be for the good of all the engineering profession. Let me reiterate what has already been said, that whether you favor professional registration or whether you despise it, it is one of the engineering facts of life today. It is unfair so to emphasize the technical to the younger student and the younger engineer that they are unaware of these facts of professional engineering.

If engineering is to emerge in the public mind from its present heterogeneous condition, where the actual practitioners are hazily grouped with a fringe of master mechanics on the one side and with pure scientists on the other, professional concepts and objectives, especially licensing, must be inculcated. I think in engineering schools, professionalism must be thought and taught at the college level.

It is surprising how many engineering professors have not taken the trouble to secure professional licenses. I hope to live to see every engineering college professor have a licensed engineer's certificate as a prerequisite of his position. I cannot see why he should not do so any more than I can see why a professor of law should expect to teach without a state board license.

I go further and hope to see sometime the prime requisite for full membership in every national engineering society the possession of a state license that the holder is in fact a legal engineer.

Language of Professional Engineer

Engineers are becoming a numerous and particular kind of people. They have a way of thought and a manner of doing things to give to this world, and I glory in it. We engineers are more alike among ourselves than we are unlike in our different branches of civil, mechanical, chemical, and so forth. Let us speak out somehow in a common professional language, that of the professional engineer.

Many years ago an English ship was wrecked on a South Sea isle, and all were drowned except one lone sailor. A number of years afterwards a rescue vessel stopped at this isle and found this lone Englishman as king of a dusky band of several hundred savages. Said the captain of the ship to the sailor, "My, my, didn't you have a hard time learning their language?"

He said, "You know, I didn't try. But it was an awful job making them speak mine."

What I ask is that we in our special technical groups get as technical and exclusive as we like, but in our professional life know that we can speak only one language, whatever our name or sign. All of us who are engineers speak the same basic language, are members of the same profession, and our hallmark is today the possession of a state license to practice engineering.

I believe that in the esteem and respect of the great American public we stand or fall together, not in our individual job but in our common viewpoint, our ethics, our relationship each to the other, and as registered engineers in our mass impact on the social order of today and tomorrow.

The audience speaks up next month! Many new ideas and slants to this subject resulted from the open discussion. The interest in engineering licensing should mean much to the young and older chemical engineer who wants to know the "why" of licensing.

EFFECT OF AIR TURBULENCE ON RATE OF EVAPORATION OF WATER*

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THE rate of vaporization of liquids into turbulent gas streams has been the subject of considerable study, due to wide interest in many practical applications of the quantitative results. The subject has been one of theoretical interest as well, since the data provide a basis of evaluation of the various theories of mass transfer and heat transfer between two phases. In a previous paper (*8*) by the present authors new data on evaporation from flat surfaces, cylinders, and spheres were presented, and the results compared with the principal data from the literature.

Transfer across the turbulent gas stream is mainly by eddy diffusion, which is rapid compared with molecular diffusion. Inasmuch as the resistance of the eddy layer is usually a substantial fraction of the total resistance, it may be expected that the nature of turbulence in the moving stream will influence the rate of transfer between phases. It is possible that the character of the turbulence may affect also the thickness of the relatively stagnant layer at the wall, in which molecular diffusion is the important mechanism of transfer.

Turbulence is generally characterized by its *scale* and *intensity*. Scale is a measure of the size of the eddies, and may be defined in various ways, as by the length L_1, where

$$L_1 = \int_0^\infty R_y dy \qquad (1)$$

Here R_y is the correlation between two values of the velocity U at two points separated by a distance y along a line normal to the direction of flow. Within an eddy the correlation is high; if y is greater than the eddy size the two velocities are in random relation to each other, and R_y is zero. A graph of R_y vs. y, therefore, is a curve falling from $R_y = 1$ at $y = 0$ to $R_y = 0$ at some finite value of y. The curve is slightly convex to the y axis, and L_1 is roughly one-half the value of y where R_y becomes zero.

Intensity of turbulence is a measure of the velocity fluctuations at a point in the stream. The velocity at any point varies rapidly with time, and momentarily may be considerably greater or less than the time-average. The extent of these variations in relation to the average velocity at the point determines the degree or intensity of turbulence. At any instant the velocity U at a point in a turbulent stream is given by

$$U = U_a \pm u \qquad (2)$$

where U_a is the average velocity, and u is the deviating velocity. The root mean square value of u, expressed by u' is a measure of the degree of fluctuation of U about the average U_a, and the intensity of turbulence is defined as u'/U_a, or the per cent turbulence as $100\ u'/U_a$.

Equipment for the measurement of both intensity and scale of turbulence is complicated and expensive; perhaps it is because of this that few data have been published on the influence of turbulence on either mass or heat transfer. Williams (*10*) quotes results of Loyzantzky and Schwab (*7*) showing the Nusselt group for heat transfer to a 7.0 cm. sphere to increase sharply (30-35%) as the per cent turbulence was increased from 0.4 to 2.8% at Reynolds numbers from 4×10^4 to 1.2×10^5. Comings, Clapp, and Taylor (*2*), using a hot wire wake-angle instrument as developed by Schubauer for the measurement of intensity of turbulence, found the Nusselt number for heat transfer to cylinders to increase as much as 25% as the per cent turbulence was varied from 1.8 to 21.6%. The increase in Nusselt number was greatest in the range from 1.8 to 4% turbulence; further increase in turbulence had much less effect. These authors also investigated the effect of turbulence on the rate of vaporization of water from a 3.32 cm. O.D. cylinder placed normal to the air stream. Results of these tests were widely scattered, but seemed to indicate about the same effect of turbulence intensity as in the case of heat transfer.

The present investigation covered the effect of both intensity and scale of turbulence on the rate of vaporization of water into air from small spheres and cylinders. It was made possible by the availability of a hot-wire turbulence meter constructed by Dr. R. L. Levine in connection with a research project for the United States Navy, Bureau of Ordnance.

Experimental Procedure

The small spheres and cylinders were supported in a 10.2 cm. I.D. high-velocity air duct and measurements made as described in the earlier paper (*8*). Data were obtained on rate of vaporization of water from the wet shapes placed near the center of the duct, where the turbulence was essentially isotropic.

Intensity of turbulence was measured by means of a hot-wire anemometer of the type initially developed by Burgers (*1*) and Dryden (*3*). The instrument depends upon the ability of a small electrically heated wire to follow velocity fluctuations with corresponding temperature and resistance changes, and the associated technique is extensively treated in the literature. In general, fluctuations in speed give rise to variations in potential drop across the wire which may be amplified and applied to suitable measuring instruments.

The amplifier used had a full gain of 200,000, variable in steps of 2 and 5 with a frequency response of 20-20,000 cycles/sec. Wires of platinum manufactured by the Wollaston technique are commercially available with a diameter of 0.0025 mm. and these were used for all probes. The wires were soldered to

* This is the second of two related articles by Maisel and Sherwood. The first one, titled, "Evaporation of Liquids into Turbulent Gas Streams," was published in the March issue of *Chemical Engineering Progress*.

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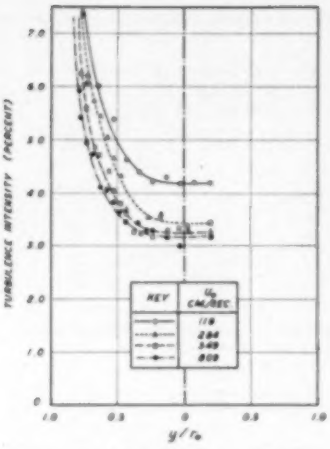

Fig. 1. Turbulence Intensity Profiles for Normal Pipe Turbulence.

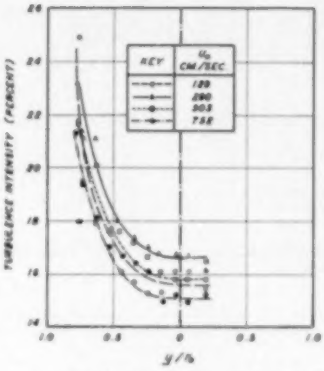

Fig. 2. Turbulence Intensity Profiles for 1.27-cm. Plate Located 33 cm. Upstream

steel supports mounted in a suitable traversing device and the silver coating was then etched with nitric acid according to the technique devised by Levine (*6*).

To provide variation in the eddy pattern, two drilled plates were prepared, the first of which consisted of holes 1.27 cm. in diameter on alternate intersections of a 1.27 cm. square grid, while the second contained 0.32-cm. holes drilled on a 0.32-cm. grid, geometrically similar to the 1.27-cm. plate. Both were constructed of lucite sheeting 0.16 cm. thick. A plate-holder was machined to a smooth fit with the inside of the test tunnel, so that the turbulence generators could be located at any optional point.

Measurements of scale and intensity then were made with the probes at different distances downstream from the plates starting at 15 hole diameters from the probe until a point was reached where normal pipe turbulence had been reestablished, i.e., when the plate was sufficiently far upstream to cause negligible disturbance at the measuring point.

All turbulence measurements were made with probes mounted in a special adapting section, similar to that used in vaporization measurements. No test object was present in the air stream during these determinations. Transfer experiments were then made in a manner described in the previous article but with the turbulence generators installed upstream of the test piece. While the turbulence around a cylinder is by no means isotropic, the effect of the eddy pattern just upstream of the evaporating area upon the transfer rate could then be determined.

Runs were made at constant velocity with varying ratios of the distance from object to generator. The first run was made with the plate sufficiently far upstream to cause no influence upon the eddy pattern at the test piece. The plate was then brought progressively closer and runs were made at certain specific locations where turbulence patterns had been measured. Finally, the plate was removed and a run was made with no turbulence generator in place. This procedure gave an excellent check for any particular series, since the first and last runs could be compared to determine the reproducibility of results. The velocity was then changed and the next series was run off.

Measurements were made with cylindrical and spherical test objects over a range of velocities from 850 to 140 cm./sec. while turbulence intensities varied from 3.5 to 23%. Corresponding variations in scale were from 0.51 to 1.27 cm.

Results of Measurements of Stream Turbulence

Turbulence intensity profiles were obtained by measuring turbulence intensity across the upper radius of the 10.2-cm. duct, at the test section. Typical data are shown in Figures 1 and 2, showing per cent turbulence vs. position for different air speeds. Figure 1 shows data obtained with normal pipe turbulence, i.e., without a turbulence generator or plate in position. Figure 2 shows similar data taken with the 1.27-cm. plate located 33 cm. upstream.

Since the evaporation test objects were located in the center of the stream, turbulence measurements in most experiments were confined to this region, and the values quoted below correspond to the central flat portion of the curves of Figures 1 and 2. Turbulence intensity was found to decrease sharply with distance downstream from the turbulence generator, but to decrease only slightly as the average velocity was increased from 100 to 850 cm./sec. Decay of turbulence downstream from the turbulence generator is indicated by the results shown in Table 1 for the two plates used. Values for turbulence intensity represent the average of results at several velocities for each plate position, and may be taken as representative of results at 500 cm./sec.

It is evident that the turbulence is somewhat higher with the 0.32-cm. plate than with the 1.27-cm. plate, for any value of L/D_p. This is probably due to the larger ratio of plate thickness to hole diameter in the plate with the smaller holes. The two curves of intensity vs. L/D_p are essentially parallel over the range covered.

For values of L/D_p of 70 and greater, data for the 1.27-cm. plate check well with the relation proposed by Dryden (*3*) for the decay of isotropic turbulence downstream from a grid:

$$\left(\frac{U_o}{u'}\right)^2 = 400\left[1 + 0.04\left(\frac{L}{D_p} - 80\right)\right] \qquad (3)$$

Here the constants have been evaluated to fit the data of Dryden (*4*), von Kármán (*5*), and Taylor (*9*). For values of L/D_p less than 60, Equation (3) gives results much higher than observed with the 1.27-cm. plate. However, the earlier data noted were obtained with woven wire screen instead of drilled plates, and D_p is taken as the wire diameter. Furthermore, the free stream turbulence preceding the screen was of the order of 1%, whereas in the present case it was 3-4%.

Measurements of the scale of turbulence with the double probe are illustrated in Figures 3 and 4, and summarized in Table 2. Figure 3 shows the correlation coefficient R_y as a function of the distance y normal to the stream, with points for several air velocities. The correlation drops to zero at about 1.5 cm., and integration under the solid curve gives a value of 0.56 cm. for the scale. Since the single curve represents the data obtained over a range of velocities with no plate in place, it follows that the scale was essentially constant at 0.56 cm. with normal pipe turbulence.

With the turbulence generators in place, the scale was found to vary with air velocity, as indicated by Figure 4, which shows R_y vs. y at two velocities

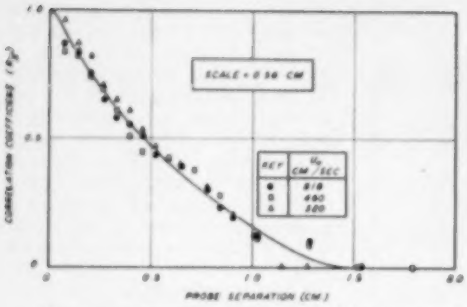

Fig. 3. R_y Plotted vs. y to Obtain Turbulence Scale. Data for three air velocities with no turbulence promoter.

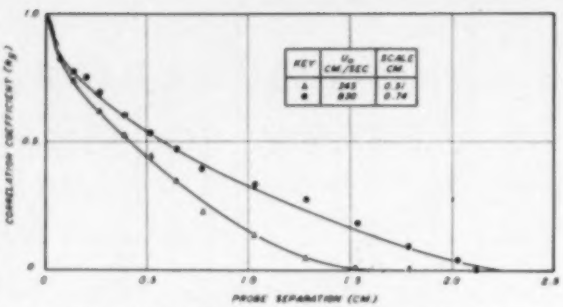

Fig. 4. Scale Determination with 1.27-cm. Plate Located 91.5 cm. Upstream.

with the 1.27-cm. plate 90 cm. upstream. Variation of scale with plate position and air velocity is indicated by the results given in Table 2. The scale is seen to be roughly equal to the diameter of the plate holes, with L_1/D_o less than unity for the 1.27-cm. plate and a little greater than unity for the 0.32-cm. plate. Scale varies considerably with the distance downstream, and increases somewhat with increase in air velocity. The principal effect noted is the reduction in scale obtained when the 0.32-cm. plate is used.

Effect of Turbulence on Mass Transfer

The effect of the 1.27-cm. plate turbulence promoter is illustrated by the data of Figure 5, showing j_D vs. Re for evaporation of water from a transverse cylinder 1.42-cm. O.D. with 22.8 sq.cm. wetted surface. The experimental points define two lines for two plate positions,

L_1, cm.	21.6	34.2	57.1	90.1	147	∞
U_c/U_o	1.09	1.10	1.17	1.20	1.25	1.27

and the dotted line represents the previous data obtained with no plate in place (normal pipe turbulence). It is evident that the effect of the plate is appreciable, especially at high Reynolds numbers with the plate near the wet test cylinder. Since the velocity profile is flattened by the presence of the plate, the center-line velocity U_c used in Re is obtained by multiplying U_o by a different factor for each plate position, as follows:

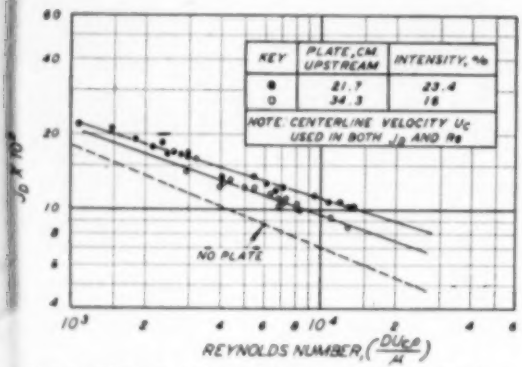

Fig. 5. Effect of 1.27-cm. Plate on Mass Transfer to Cylinders.

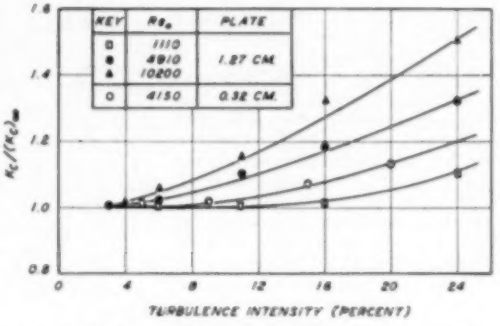

Fig. 6. Effect of Turbulence on Mass-Transfer Coefficients for Cylinders.

TABLE 1.—DECAY OF TURBULENCE DOWNSTREAM FROM TURBULENCE GENERATOR

(Air Velocity 100 to 850 cm./sec.)

D_p, Plate, cm.	Distance Downstream, cm. (L)	$\frac{L}{D_p}$	Average % Turbulence
1.27	21.6	17	23.4
1.27	34.2	27	16.0
1.27	57.1	45	11.0
1.27	90.1	71	6.6
1.27	147	116	3.8
0.32	9.5	30	20.0
0.32	14.0	44	15.0
0.32	34.2	107	9.0
0.32	57.1	179	5.0
No plate	....	....	3.5

TABLE 2.—SCALE OF TURBULENCE DOWNSTREAM FROM PLATE TURBULENCE GENERATORS

D_p, Plate cm.	Distance Downstream (L), cm.	U_o cm./sec.	Scale (L_1), cm.	$\frac{L}{D_p}$	$\frac{L_1}{D_p}$
1.27	21.6	533	1.09	17	0.86
1.27	21.6	826	1.25	17	0.98
1.27	34.2	845	0.84	27	0.66
1.27	57.1	845	0.76	45	0.60
1.27	57.1	825	0.99	45	0.78
1.27	90.1	345	0.51	71	0.40
1.27	90.1	830	0.74	71	0.58
0.32	9.5	308	0.35	30	1.10
0.32	9.5	791	0.43	30	1.35
0.32	34.2	386	0.33	107	1.03
0.32	34.2	835	0.41	107	1.35
0.32	57.1	379	0.41	179	1.28
0.32	57.1	820	0.54	179	1.68
No plate	....	320–818	0.56	..	....

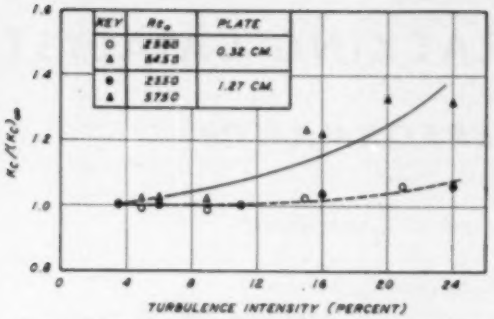

Fig. 7. Effect of Turbulence Intensity and Scale on Mass-Transfer Coefficients for Spheres.

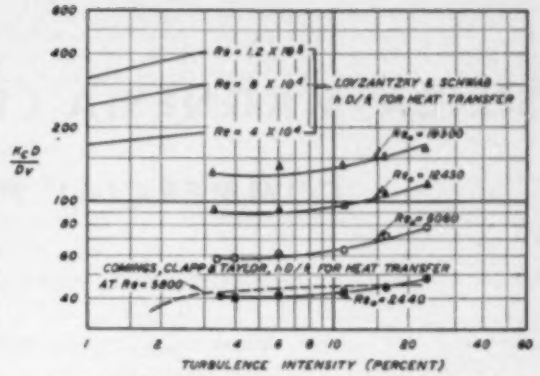

Fig. 8. Effect of Turbulence Intensity on Mass-Transfer Coefficient for Spheres.

Figures 6 and 7 show typical data plotted to indicate the fractional increase in K_c as turbulence intensity is increased, with both 1.27-cm. and 0.32-cm. plates. K_c is the observed value of the mass-transfer coefficient, and $(K_c)_o$ is the value with no plate in place, i.e., with the normal pipe turbulence of 3.5%. At the higher Reynolds numbers K_c is increased as much as 50% as the per cent turbulence is increased from 3.5 to 24%. Scale of turbulence apparently has little effect, since the results for the two plates fall in line in spite of the twofold variation in resulting scale. The effect of turbulence intensity is actually a little greater than indicated by these two graphs, since the lines are for constant U_a rather than for constant U_c; at constant Re_o the air velocity past the wet object is some 14% less at 24% turbulence than with no plate in position.

Data on evaporation of water from a single wet 2.55-cm. O.D. sphere are shown in Figure 8 plotted as K_cD/D_v vs. per cent turbulence for constant values of Re_o. Increasing the per cent turbulence from 3.5 to 24 causes K_c to increase 18% at a Reynolds number of 2440, and 25% at 19,500. Again the actual effect is somewhat greater than indicated, since U_c/U_a is smaller at the higher values of per cent turbulence. However, it is evident that the effect of turbulence is slightly less for spheres than for cylinders, and that the variation of the effect with Re is less.

The effect of turbulence on heat transfer to cylinders as found by Loyzantzky and Schwab (*7*) for spheres and by Comings, Clapp, and Taylor (*2*) for cylinders is indicated on Figure 8. The former obtained a marked effect of turbulence in the range of 1 to 3%, with no data for the higher range. Comings, Clapp, and Taylor obtained a marked increase in hD/k in the range 1.8 to 4% turbulence, with little further increase as the turbulence intensity was increased up to 21%. Their line, therefore, is of the opposite curvature to the lines representing the present data. It appears the complete curve may be *S*-shaped, with relatively steep slopes below 3% and above 15-20% turbulence.

There is no pertinent theory of mass transfer to spheres and cylinders with which to compare the present data. However, it would appear that variations in turbulence intensity are felt in the buffer and laminar layers where most of the resistance to interphase diffusion is located, but that changes in scale in the main stream have little effect in these layers, so that scale affects only eddy diffusion in the fully turbulent core, which represents but a fraction of the total resistance.

Notation

D = diameter of cylinder or sphere, cm.

D_p = diameter of holes in turbulence promoter plate, cm.

D_v = molecular diffusivity, sq.cm./sec.

$j_D = \dfrac{K_c p_{BM}}{U_a P}\left(\dfrac{\mu}{\rho D_v}\right)^{2/3}$

K_c = mass-transfer coefficient, g. moles/(sec.) (sq.cm.) (g. mole/cu.cm.)

$(K_c)_o$ = value of K_c with no turbulence promoter

L = distance from turbulence promoter to test object, cm.

L_1 = scale of turbulence, as defined by Eq. (1), cm.

p_{BM} = log mean partial pressure air in film, atm.

P = total pressure, atm.

r_o = radius of conduit, cm.

R_y = correlation between two values of U at two points separated by a distance y normal to the stream velocity

Re = Reynolds number based on diameter of cylinder or sphere

Re_o = Reynolds number based on average velocity, U_a

u = deviating velocity, cm./sec.

u' = root mean square value of u, cm./sec.

U = time average velocity, cm./sec.

U_c = velocity at center line, cm./sec.

U_a = average velocity in conduit, cm./sec.

y = distance normal to direction of flow, cm.

μ = viscosity of air, g./(sec.) (cm.)

ρ = density of air, g./(cu.cm.)

Literature Cited

1. Burgers, J. M., *Konink Akad. Wetenschap Amsterdam*, **29**, 547 (1926).
2. Comings, E. W., Clapp, J. T., and Taylor, J. F., *Ind. Eng. Chem.*, **40**, 1076 (1948).
3. Dryden, H. L., *Quart. Appl. Math.*, **1**, 7 (1943).
4. Dryden, H. L., and Kuethe, A. M., *Tech. Rep.* No. 320, *Nat. Advisory Comm. Aeronaut.* (1929).
5. Von Kármán, Th., *Proc. 5th Intern. Congr. Appl. Mech.*, p. 347 (1938).
6. Levine, R. L., Sc.D. Thesis in Chem. Eng., Mass. Inst. Tech. (1948).
7. Loyzantzky, L. D., and Schwab, B. A., *Central Aerodynamic Hydraulic Inst. (U.S.S.R.), Rept.* 329 (1935).
8. Maisel, D. S., and Sherwood, T. K., *Chem. Eng. Progress*, **46**, No. 3, 131 (1950).
9. Taylor, G. I., *Proc. Roy. Soc. (London)*, **151**, 421 (1935).
10. Williams, G. C., Sc.D. Thesis in Chem. Eng., Mass. Inst. Tech. (1942).

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SILICA-MAGNESIA CRACKING CATALYST

COMMERCIAL PERFORMANCE

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The first significant commercial operation of the fluid-catalyst cracking process employing silica-magnesia catalyst has been carried out for a 315-day period in a 25,000 bbl./day unit by the Standard Oil Co. (Ind.). With this catalyst, higher gasoline yields, lower butane and gas yields, and lower octane numbers were obtained compared with silica-alumina. Although silica-magnesia demonstrated the anticipated high activity maintenance and immunity to sulfur poisoning, an unfavorable trend toward decreased regeneration efficiency was observed which ultimately resulted in the termination of the operation. Further research is being carried out to determine the causes and possible cures for low regeneration efficiency.

PRIOR to May, 1948, only two types of catalysts had been employed in commercial fluid-catalyst cracking units; these were synthetic silica-alumina catalyst and acid-treated montmorillonite clay, referred to as natural catalyst.* However, in the research laboratories of Standard Oil Company (Indiana) several other types of catalysts have been evaluated; of these one of the most promising has been synthetic silica-magnesia. This experimental work on silica-magnesia catalyst, which has been in progress for more than ten years, has included:

1. Investigation of catalyst preparation (*2*).
2. Preliminary evaluations, carried out in small fixed-bed catalyst-testing units, of activity, selectivity, aging characteristics, and resistance to poisons.
3. Investigation of activity, product distribution, and product quality in fixed-bed pilot plants employing about 5.5 l. of catalyst.
4. Laboratory investigations of such physical characteristics as density, attrition resistance, aeration properties, specific surface, and pore size.
5. Thorough investigation in a 2 bbl./day fluid-catalyst pilot plant of activity maintenance, product distribution, product quality, regeneration characteristics, and resistance to poisons.

In view of the favorable results obtained, these investigations culminated in a full-scale commercial trial of silica-magnesia catalyst in a 25,000 bbl./day fluid-catalyst cracking unit of the Standard Oil Co. (Ind.) It is the purpose of the present paper to outline the experimental background which led to the decision to test silica-magnesia commercially, and to discuss the commercial experience with this catalyst.

Exploratory Work

Exploratory work on silica-magnesia catalyst herein discussed included investigation of stability to various treatments, distribution and quality of products, effect of sulfur, and physical characteristics. Results of this work indicated two outstanding advantages of silica-magnesia catalyst over silica-alumina and natural catalysts; namely, higher gasoline yields and exceptional resistance to steam deactivation. On the other hand, silica-magnesia was found to have the disadvantage of producing gasoline of lower octane number. These points are illustrated in Tables 1 and 2.

Determination of Activity and Selectivity. The bench scale activity and selectivity ratings reported in Table 1 and subsequent parts of this paper were determined according to a test method which has been previously described (*10*).

The experimental procedure is briefly as follows:

A standard Mid-Continent virgin gas oil (214 ml.) is passed downflow through a weighed sample (80 ml. bulk volume) of catalyst powder during a 60-min. reaction period at 930° F.; the liquid product is recovered and distilled to determine the extent of cracking (conversion); and the yields of carbon and gas are determined.

Indiana relative activity is defined as the number of grams of a reference catalyst required to achieve the same degree of cracking as 100 g. of test catalyst under otherwise identical operating conditions. This involves the concept of activity units which are proportional to weight of catalyst; for example 200 g. of 50-activity catalyst will accomplish the same degree of cracking as 100 g. of 100-activity catalyst.

Carbon factor of a catalyst is defined as the ratio of the carbon yield (wt. %) obtained in the fixed-bed cracking run with the test catalyst to the carbon yield obtained with the standard reference catalyst at the same conversion of gas oil. Gas factor is defined as the ratio of gas yield (cubic feet per barrel of feed) obtained with the test catalyst to the gas yield obtained with the standard reference catalyst at the same conversion of gas oil.

Cracking activity and selectivity tests reported in Table 1 were carried out on the catalysts in exactly the same form as charged to a commercial fluid catalytic cracking unit; that is, the catalysts were tested as powders and no fines were removed.

Effects of Heat and Steam on Activity and Selectivity. Table 1 shows comparative bench-scale activity ratings and selectivity factors for the three types of catalysts after various conditioning

* Both types of catalyst are widely used commercially. The synthetic silica-alumina catalyst is manufactured by the American Cyanamid Co., New York, N. Y.; Davison Chemical Corp., Baltimore, Md., and National Aluminate Corp., Chicago, Ill. The natural catalyst is supplied by the Filtrol Corp., Los Angeles, Calif.

treatments. These data indicate that silica-magnesia compares with natural catalyst and silica-alumina as follows:

1. Initial activity	higher than natural catalyst, lower than silica-alumina
2. Resistance to steam deactivation	far superior to both (up to at least 1200° F.)
3. Resistance to dry-heat deactivation	equal to natural catalyst, inferior to silica-alumina *
4. Carbon-producing tendency	intermediate between natural catalyst and silica-alumina
5. Gas-producing tendency	less than either natural catalyst or silica-alumina

* Since the maximum normal operating temperature (in regenerator) in commercial fluid-catalyst units is only 1050-1100° F., all three catalysts appear to possess adequate dry-heat stability.

Distribution and Quality of Products. Typical product distributions and gasoline inspections, obtained with the three catalysts in a fixed-bed catalytic-cracking pilot plant employing 5.5 l. of catalyst, are presented in Table 2. In this investigation, the catalysts were tested in the form of ¼-in. cylindrical pills of about 45 lb./cu.ft. bulk density. It is apparent that, at equal conversion, silica-magnesia gave the highest yield of 10-lb. (Reid vapor pressure) gasoline and the lowest yields of excess butanes † and dry gas. Silica-alumina was at the opposite extremes in these respects and natural catalyst was intermediate. Additional data (not shown) obtained in the fixed-bed pilot plant indicate that these differences became more pronounced when conversion was increased, and also that, at conversions above 65%, silica-magnesia gave less coke than either silica-alumina or natural catalyst.

Gasoline inspections given in Table 2 show that 10-lb. gasoline produced by cracking with silica-magnesia had a substantially lower front-end volatility, a research octane number (clear) about 5 units lower, and a motor octane number (clear) about 2 units lower than the 10-lb. gasoline produced by cracking with silica-alumina; natural catalyst was again intermediate. Upon addition of tetraethyl lead (*TEL*), the motor-octane disadvantage of silica-magnesia was considerably reduced. Similar conclusions with regard to the comparative laboratory performances of silica-magnesia, silica-alumina, and natural catalyst have been reported also by others (*1, 9*).

† The term "excess butanes" as used herein signifies butanes + butenes in excess of the quantity that can be included in the gasoline, as limited by vapor-pressure specification.

Effect of Sulfur. All cracking data discussed thus far were obtained on low-sulfur feed stocks. Inasmuch as the average catalytic-cracking feed stock projected for use with silica-magnesia catalyst contained about 1.5% sulfur, and particularly in view of the fact that one of the commercial cracking catalysts —natural catalyst—was known to be susceptible to sulfur poisoning (*4-6*), it was important to investigate resistance of silica-magnesia catalyst to sulfur poisoning. Results of such exploratory work indicated that, under certain conditions, some sulfur compounds did indeed lower the activity and increase the coke-producing tendency of silica-magnesia catalyst, but that steam was effective in combatting this deterioration. This is illustrated by the example shown in Table 3, which indicates that exposure to hydrogen sulfide at one atmosphere for one hour at 900° F. lowered the cracking activity by about 35% and approximately doubled the carbon-producing and gas-producing tendencies. Steaming the catalyst after the treatment with hydrogen sulfide and before subsequent exposure to air restored the catalyst quality to its original state.*

These results indicated that process steam and stripping steam in the fluid-catalyst operation might adequately protect silica-magnesia catalyst against sulfur poisoning. It was recognized, however, that steam partial pressure and the contact time of steam with catalyst

* Similar results were obtained with natural catalyst, but in that case the steam, although beneficial, was less effective in reversing the deleterious effect of hydrogen sulfide. Fresh silica-alumina is relatively immune to hydrogen sulfide.

TABLE 1

BENCH-SCALE COMPARISON OF CATALYSTS

Effect of Heat and Steam on Activity and Selectivity

Catalyst	Silica-Magnesia	Natural	Silica-Alumina
After 4 Hrs. Dry Air at 1000°F			
Indiana Relative Activity	112	69	141
Carbon Factor	1.1	1.3	1.2
Gas Factor	1.0	1.2	1.1
After 3 Hrs. Steam at 1000°F and 1 Atm.*			
Indiana Relative Activity	101	64	128
Carbon Factor	1.0	1.1	0.8
Gas Factor	0.9	1.1	1.0
After 16 Hrs. Steam at 1200°F and 1 Atm.			
Indiana Relative Activity	107	36	40
Carbon Factor	0.8	1.4	0.5
Gas Factor	0.8	1.4	0.8
Max. Calcination Temp. in Dry Air Without Drastic Loss of Activity	1400	1400	1600

* Bench-scale results after this pretreatment are believed to give the most reliable indication of initial performance in commercial operation.

TABLE 2

COMPARISON OF CATALYSTS IN FIXED-BED PILOT PLANT

Catalytic Cracking of 32.2° API Mid-Continent Virgin Gas Oil at 900°F, Atmospheric Pressure, 20-min. Reaction Period, 10 wt. % Process Steam

Conversion, vol. % *	50		
Catalyst	Silica-Magnesia	Natural	Silica-Alumina
Product Yields			
Gasoline (10-lb. R.V.P., 400°F E.P.), vol. %	47.4	43.6	41.0
Excess Butenes, vol. %	1.6	4.8	7.0
Dry Gas (C_2 and Lighter), wt. %	5.4	6.5	7.9
Catalytic Gas Oil, vol. %	50.0	50.0	50.0
Coke, wt. %	2.6	2.8	1.9
Gasoline Inspections			
% Evap. at 158°F (ASTM Dist.)	24.5	30.0	40.0
Motor Octane No. (F-2), Clear	80.0	80.2	82.3
with 1 cc TEL/gal.	83.0	82.8	84.0
with 3 cc TEL/gal.	85.4	85.1	86.3
Research Octane No. (F-1), Clear	88.6	91.6	93.5

* Conversion = 100 minus vol. % Catalytic Gas Oil

TABLE 3

EFFECT OF H_2O ON SILICA-MAGNESIA CATALYST

Treatment Prior to Cracking Test	Indiana Relative Activity	Carbon Factor	Gas Factor
Dry Air at 1000°F (a)	88	0.8	0.9
H_2O, followed by dry air (b)	57	1.6	1.7
H_2O, followed by steam (c)	92	0.8	1.0

(a) Calcined 3 hrs. at 1000°F in dry air.

(b) Exposed to H_2O for 1 hr. at 930°F and 1 atm., followed by 3 hrs. at 1000°F in a stream of dry air.

(c) Exposed to H_2O for 1 hr. at 930°F and 1 atm., then immediately steamed 3 hrs. at 930°F, and finally calcined 3 hrs. at 1000°F in a stream of dry air.

TABLE 4

INSPECTION DATA ON FEED STOCK USED IN PILOT-PLANT COMPARISON OF CATALYSTS

Gravity, °API	29.6
ASTM Distillation	
IBP, °F	430
10%	479
30	529
50	602
70	666
90	746
Sulfur, % (Bomb)	1.16
Aniline Point, °F	151
Carbon Residue, Conradson, %	0.09
Ash, %	0.0
Viscosity, SUS at 100°F	51
Flash, °F (Open Cup)	170
Gasoline, vol. % *	10.2

* By Laboratory Fractionation

would be much lower in fluid-catalyst operation than in the exploratory experiments; it was therefore necessary to investigate this problem more fully in the fluid-catalyst pilot plant. The problem is continuing to receive attention in the laboratory from the standpoint of determining whether sulfur from the feed in any way impairs either cracking characteristics or regeneration efficiency—particularly when the catalyst, after prolonged use, has suffered the normal accumulation of such contaminants as iron.

Physical Characteristics. The specific surface † of fresh silica-magnesia is of the order of 500-600 sq.m./g., which is about the same as that of fresh silica-alumina and roughly 1.5-2.0 times that of fresh natural catalyst. The mean pore diameter—calculated from specific surface and total micropore volume, assuming cylindrical pores—is about 30-35 Angstrom units, compared with 40-50 Angstrom units for silica-alumina and natural catalyst. Changes in specific surface of the three catalysts that accompany the various calcination treatments parallel closely the changes in activity shown in Table 1. On the other hand, whereas the mean pore diameters of silica-alumina and natural catalyst increase considerably upon steaming, the mean pore diameter of silica-magnesia remains relatively constant. Some of these observations have been reported also by others (*9, 11*).

The most significant data on such physical characteristics of silica-magnesia catalyst as density, flow properties, and attrition resistance were obtained on silica-magnesia produced in a commercial catalyst-manufacturing plant.* Laboratory data on fresh catalyst indicated that the aerated density of silica-magnesia—as determined in a 1.5-in. glass fluidization column—is appreciably higher than that of silica-alumina, and that the attrition resistance of silica-magnesia—as determined in a laboratory accelerated attrition test (*7*)— is considerably better than that of silica-alumina. The superiority of silica-magnesia in the latter respect is especially pronounced after the catalyst has been calcined at a temperature of 1300-1350° F.

Another interesting change that was found to occur on calcination of silica-magnesia was a marked decrease in the tenacity of oil adsorption, despite an appreciable increase in catalytic-cracking activity. Thus, when the fresh silica-magnesia catalyst, after 4 hours' calcination at 1000° F. in dry air, was subjected to the regular bench-scale activity test (which included 10 minutes stripping with nitrogen at 930° F. subsequent to the one-hour passage of oil), the catalyst still retained about 0.7-0.8 wt. % oil that could be extracted with acetone. On the other hand, when this catalyst was first calcined 4 hr. at 1200-1400° F. in either dry or moist air and then subjected to the same test, the extractable oil not removed by stripping amounted to only 0.1-0.25%. A similar observation was made in the work with the fluid-catalyst pilot plant. Fortunately, the oil-retaining tendency of

† Specific surface and pore size were determined by means of low-temperature adsorption of nitrogen (*3*).

* All the silica-magnesia catalysts used in pilot-plant and commercial operations were prepared by the Davison Chemical Corp.

TABLE 5

COMPARISON OF CATALYSTS IN 2-B/D FLUID PILOT PLANT

900°F Reactor Temperature; 50% Conversion *

Catalyst	Silica-Magnesia	Natural	Silica-Alumina
Indiana Relative Activity	65	24	34
Carbon Factor	0.83	1.15	1.00
Gas Factor	0.95	1.10	1.15
Product Yields			
Gasoline (10-lb. R.V.P., 400°F E.P.), vol.%	49.0	46.5	43.0
Excess Butanes, vol. %	3.8	6.1	9.4
Total Butanes, vol. %	7.8	9.5	12.4
Dry Gas (C_3 & Lighter), wt. %	5.4	5.9	6.9
Gas Oil, vol. %	44.9	44.9	44.9
Coke, wt. %	4.1	4.4	4.2
Octane Numbers of Gasoline			
Motor (F-2), Clear	76.6	77.6	78.2
" with 1.0 cc TEL/gal.	80.2	80.8	80.8
" with 3.0 cc TEL/gal.	82.9	81.5	82.8
Research (F-1), Clear	85.2	88.4	90.3
" with 1.0 cc TEL/gal.	89.2	92.2	93.6
" with 3.0 cc TEL/gal.	92.8	94.7	95.8

* Corrected to gasoline-free feed

TABLE 6

INSPECTION DATA ON SILICA-MAGNESIA CATALYSTS

	Experimental Batch	Commercial Production
Indiana Relative Activity	88	106
Carbon Factor	0.80	0.87
Gas Factor	0.91	0.92
Roller Analysis		
0-10 micron, %	9.2	4.8
10-20 " "	10.0	6.9
20-40 " "	17.7	13.3
40-80 " "	27.6	25.1
80+ " "	35.5	49.9
Screen Analysis		
On 80 mesh, %	0.7	0.2
80-100 " "	1.4	1.9
100-200 " "	26.7	50.5
200-325 " "	20.6	15.0
Thru 325 " "	50.6	32.4
Density, lbs. per cu. ft.		
Settled	50.5	34.0
Compacted	77.5	47.8
Aerated at 0.3 ft./sec.	36.8	20.0

TABLE 7

TYPICAL INSPECTION DATA ON FEED STOCK USED IN COMMERCIAL OPERATIONS WITH SILICA-MAGNESIA CATALYST

Gravity, °API	27.7
ASTM Distillation	
IBP, °F	406
10%	458
30	570
50	630
70	696
90	756
Sulfur, % (Bomb)	1.52
Aniline Point, °F	150.5
Carbon Residue, Conradson, %	0.19
Ash, %	0.05
Viscosity, SSU at 100°F	59
Flash, °F (Open Cup)	220
Gasoline, vol. %	4.8

TABLE 8

COMPARISON OF CATALYSTS IN COMMERCIAL UNIT

Coke-Burning Rate: 20,000 lbs./hr.

Charge Rate, B/D	25,000		30,000		
Catalyst	Silica-Magnesia	Silica-Alumina	Silica-Magnesia	Silica-Magnesia	Silica-Alumina
Operating Conditions					
Reactor Temperature, °F	900	900	925	925	900
Catalyst-to-Oil Ratio	5.0	5.0	7.0	7.0	5.0
Space Velocity, $W_o/hr./W_c$	2.7	0.6	2.7	3.2	1.0
Conversion, % *	51.0	49.8	52.3	44.2	43.5
Product Yields					
Gasoline, vol. %	46.2	39.0	45.7	40.2	36.6
Excess Butanes, vol. %	2.8	8.0	3.8	2.6	5.8
Cycle Stocks, vol. %	46.0	47.2	44.8	52.4	53.1
Dry Gas (C_2 & Lighter), wt. %	6.1	7.4	6.8	5.9	6.5
Coke, wt. %	6.2	6.2	6.2	5.1	5.1
Octane Numbers of Gasoline (10-lb. R.V.P., 400 E.P.)					
Motor (F-2), Clear	77.2	78.8	78.2	77.8	78.3
" with 1.5 cc TEL/gal.	81.2	82.5	82.0	81.7	82.1
Research (F-1), Clear	85.9	91.0	87.0	86.6	90.7
" with 1.5 cc TEL/gal.	91.0	95.4	92.1	91.8	95.1

* Corrected to gasoline-free feed

fresh silica-magnesia catalyst was found to diminish rapidly in commercial use and, therefore, was not a serious problem.

Pilot-Plant Evaluation

The promising results shown in the exploratory work described above indicated that silica-magnesia might be successfully employed with high-sulfur feed stocks. Before this catalyst could be recommended for commercial operation, however, it was necessary to carry out pilot-plant tests to determine the effects, over an extended period of time, of high-sulfur feed stock on (a) properties of the catalyst, (b) cracking yields, and (c) regeneration characteristics in fluid operation. As indicated below, other questions that required pilot-plant investigation arose after the start of commercial operations.

Results with Experimental Batch of Silica-Magnesia. The pilot-plant data were obtained on a 2 bbl./day fluid-catalyst unit which has been described in a previous paper (*4*). The feed stock employed was typical of that used for commercial operations, and consisted of a mixture of virgin gas oil and gas oil from delayed coking of reduced crude; both gas oils were predominantly of West Texas origin. Inspection data on the feed stock are given in Table 4. The silica-magnesia catalyst was a portion of an experimental batch supplied by the manufacturer to a number of laboratories.*

The pilot-plant catalytic-cracking tests at this laboratory were carried out continuously over a period of 655 hr., during the first 577 of which no fresh-catalyst additions were made. During this period the Indiana relative activity (*10*) declined from 88 to 53, while the carbon factor remained essentially constant at 0.8. These data indicated good maintenance of activity and excellent maintenance of selectivity, and demonstrated that the high-sulfur stock had no harmful effect upon the catalyst.

Cracking yields which were obtained are presented in Table 5, in which comparison is made with silica-alumina and natural catalysts on the same feed stock at 50% conversion. It will be noted that the silica-magnesia at 900° F. gave 49% gasoline, compared with 46.5% for natural catalyst and 43% for silica-alumina. It is also of interest that data at higher conversions showed an even greater spread between the silica-magnesia and silica-alumina catalysts, the difference at 60% conversion being 11% gasoline—based on feed—compared with 6% at 50% conversion. This indicates that higher conversions may be desirable for silica-magnesia.

Comparison of coke yields at 50% conversion reveals no significant differences among the three catalysts. Yields of butane and dry gas were highest for silica-alumina and lowest for silica-magnesia, with the greatest spread in the high-conversion ranges; these yield differences compensate for the difference in gasoline yields.

The octane number of the gasoline was significantly lower with silica-magnesia than with silica-alumina, particularly on the research basis, but the difference decreased at higher *TEL* levels. In all cases, natural catalyst was intermediate between the other two catalysts. It will be noted that these results bear out the trends shown in the exploratory work. The somewhat lower octane numbers shown in Table 5, compared with the results given in Tables 2 and 8, are attributed to the presence in the pilot-plant feed of 10% gasoline, which undergoes little octane improvement under normal cracking conditions. The presence of this gasoline in the feed also tends to reduce differences in octane numbers obtained with the three catalysts.

In actual commercial operation, as discussed later, it was possible with silica-magnesia to achieve an even greater gasoline-yield advantage and a smaller octane-number disadvantage than shown in the above comparison at constant temperature and constant conversion. This situation arose from the fact that, with silica-magnesia, operations at a given feed rate and coke-burning capacity could be carried out at higher temperature and higher conversion than with silica-alumina.

During the pilot-plant runs, it was found that the coke-burning rate for silica-magnesia was essentially the same as for silica-alumina catalyst.

Results with Commercial Batch of Silica-Magnesia. As a result of these pilot-plant studies, which indicated silica-magnesia to have advantages over silica-alumina catalyst, it was decided to conduct a trial commercial run. In preparation for this run, approximately 1200 tons of silica-magnesia were ordered from the Davison Chemical Corp. Since this represented the first large-scale

* Results of tests on this catalyst with low-sulfur feed stocks in a 100 bbl./day pilot plant have already been reported (*9*).

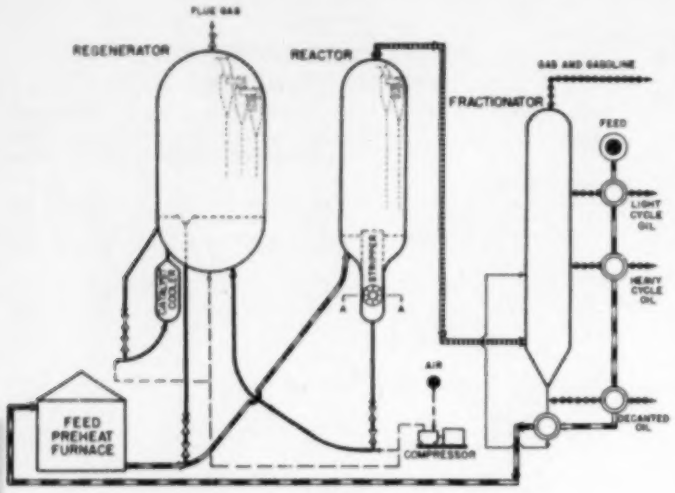

Fig. 1. Commercial Fluid Catalytic Cracking Unit.

manufacture of silica-magnesia catalyst, and since it was known that some alterations in the manufacturing procedure had been adopted, further pilot-plant tests were conducted on a representative sample of the commercial production. In addition to checking on the quality of the commercial catalyst, these tests also made it possible to obtain additional information on the conditions required for the startup of the commercial unit.

Inspection data on the commercial catalyst are compared in Table 6 with those on the experimental batch of silica-magnesia. It will be noted that the activity of the commercial batch was considerably higher and the carbon factor was slightly higher than that of the experimental batch. Although the particle-size distribution was not greatly different, the aerated density of the commercial catalyst was considerably lower than that of the experimental batch—presumably because of lower particle density. It was later found that at least part of this difference could be attributed to the fact that the experimental batch had been calcined for 6 hr. at 1350° F. to a moisture content of 2.8%, whereas the commercial batch was dried at a much lower temperature to a moisture content of about 13%.

The pilot-plant tests on the commercial batch, which were carried out over a 316-hr. period, showed excellent maintenance of catalyst properties. The activity only declined from 106 to 101, and the carbon factor—instead of increasing—actually declined from 0.87 to 0.78. Cracking yields followed the same trends as for the experimental batch of catalyst, except that coke yields were somewhat higher; the difference varied up to about 1.5% on feed in the higher-conversion ranges. This led to a thorough examination of stripping operations with the commercial catalyst, wherein it was found that the coke yields could not be significantly reduced—even with unusually high stripping-steam rates. The difference in coke yields between the commercial and experimental catalysts may have been associated with the difference in heat treatment of the two catalysts.

Some evidence for this point was indicated by the fact that, in pilot-plant operation with commercial catalyst, the spent catalyst from the stripper contained appreciable amounts of oil that could be extracted with acetone. On the other hand, the experimental batch contained only minor amounts, as observed with silica-alumina catalyst. It was found also that about twice as much oil was adsorbed at 850° F. as at 900° F. Fortunately, this oil-adsorbing tendency became negligible within a short time during commercial operations, and therefore had little effect on the commercial performance of silica-magnesia catalyst. Prior to commercial operation, however, it was felt that stripping might be a problem, and it was projected that initial operations be carried out at the maximum temperature and the maximum stripping-steam rate practicable. Examination of the pilot-plant severity-conversion data also indicated that it would be necessary to operate the commercial unit at the highest possible space velocity. The manner in which these conclusions were applied is presented below in further detail.

Description of Commercial Unit

A simplified flow diagram of the catalytic cracking unit employed for the first commercial test of silica-magnesia catalyst is shown in Figure 1. In general, the plant is typical of downflow fluid-catalyst units (*8*). A feed-preheat furnace is provided to vaporize partially and heat the feed to 725° F., and thus permit relatively low catalyst-to-oil ratios. In addition, large recycle-catalyst coolers are furnished to give flexibility in the control of the regeneration temperature. The catalyst-recovery facilities are somewhat modified from those normally employed in fluid catalytic cracking units. In the regenerator, cyclones in three stages are provided to recover catalyst from the flue gas, and the usual Cottrell precipitator has been omitted. In the reactor, two stages of cyclones are employed to reduce the carryover of catalyst to the fractionator. The spent-catalyst stripper is designed as an integral part of the reactor vessel and contains eight vertical cells, each equipped with a stripping-steam spider.

Although the unit was originally designed for a capacity of 20,000 bbl./day, charge rates up to 35,000 bbl./day have been employed, depending upon the availability of feed stock, activity of the catalyst, and other considerations dictated by ever-changing refinery situations. The reactor temperature has ordinarily been maintained in the range of 900 to 950° F., although during startup periods with active catalyst, temperatures as low as 850° F. have been employed. Considerable flexibility has existed in the amount of catalyst maintained in the reactor. With very active catalyst, the minimum holdup of 50 tons has usually been employed; with less active material the holdup has approached the higher figure of 250 tons. Catalyst-to-oil ratios have been varied from about 4.5 to 8.5, in accordance with the activity of the catalyst, space velocity, and the desired reaction temperature. Dispersion steam has normally been about 3000 lb./hr., although it was raised as high as 16,000 lb./hr. during early operations in an attempt to obtain maximum space velocity. The amount of stripping steam used in the reactor, which has ranged from 10,000 to 18,000 lb./hr., has varied with the amount of catalyst being circulated.

In the regenerator the temperature has been held usually between 1025° F. and 1050° F. The latter value is the maximum permissible, as limited by the carbon-steel construction of the standpipes and cyclones. The pressure in the regenerator has been maintained in the range of 9 to 14 lb./sq.in. to control the gas velocity between 1.3 and 1.5 ft./sec. As in the reactor, the holdup of catalyst

in the regenerator can be varied from 450 to 550 tons, as dictated by various factors which arise during normal operations. Catalyst-circulation rates have been maintained usually between 10 and 22 tons/min.; the higher figure is about the maximum consistent with permissible erosion rates in the carrier lines. The coke-burning rate has been maintained at the maximum at all times; however, because of atmospheric changes, the rate varies from 17,000 to 21,000 lb./hr. between summer and winter.

Startup of Commercial Unit

Normal Procedure. In general, fluid catalytic cracking units are brought on stream with used, low-activity catalyst. Units of the type shown in Figure 1, however, have been started up with fresh silica-alumina catalyst on several occasions. The procedure with the fresh silica-alumina catalyst involves the addition of catalyst to minimum operable levels in both the reactor and regenerator. After circulation is established, oil preheated to the maximum permissible temperature is charged to the reactor. The reactor temperature is controlled at about 850° F. by the rate of catalyst circulation from the regenerator; experience has proved this temperature to be the practical minimum without excessive coke production. The charge rate to the unit is increased under these conditions until the rate of coke formation in the reactor is equal to the maximum coke-burning capacity of the regenerator. Silica-alumina catalyst decreases in activity rapidly, so that maximum throughput on the unit has been obtained in about fifteen days; it has then been possible to increase the reactor temperature to the desired 900° F. level in an additional ten days.

Modified Procedure with Silica-Magnesia. On the basis of the previously described pilot-plant work carried out on the commercial batch of silica-magnesia catalyst, it was recognized that certain modifications should be made in the startup procedure to be used with silica-magnesia catalyst. Examination of the pilot-plant severity-conversion data indicated that it would be necessary to operate the commercial unit at the highest possible space velocity; this operation would require lowering the catalyst holdup in the cracking zone to the absolute minimum. Because of the particular design of the reactor vessel, about 40 tons of catalyst are unavoidably held up below the reactor grid, and about 10 tons above the grid. To insure minimum catalyst in the reactor, certain changes were made in the reactor instrumentation. Automatic control of the catalyst level in the system was changed to the stripper section from the reactor section above the grid. This method of control insured minimum bed height with maximum stripper level.

It was also recognized that the cracking rate could be held down in the reactor if a highly refractory feed were charged. The feed stock employed during the startup was therefore made as refractory as possible by including the heavy cycle stock from another catalytic cracking unit operating with silica-alumina catalyst.

Catalyst was charged from storage hoppers to the regenerator in the normal manner, and catalyst circulation was established. Preheated oil from the furnace was then charged to the system, and the reactor temperature was immediately brought up to 900° F. This temperature was chosen as the minimum desirable in view of the tendency for the silica-magnesia catalyst to adsorb oil which cannot be removed by stripping at lower temperatures. The oil rate was increased until the coke-burning capacity of the regenerator (20,000 lb./hr. at 1050° F.) was reached. Catalyst holdup in the reactor was maintained at the minimum of 50 tons. Because of the high catalyst activity, cracking conditions were so severe and coke production was so high that only about 10,000 bbl./day to 14,000 bbl./day of gas oil could be processed during the first ten days, with the reactor operating at 900° F.

At the end of this period, catalyst samples taken from the spent-catalyst standpipes showed that the catalyst contained very little adsorbed oil. This finding made it possible to lower the reactor temperature to 865° F., which in turn permitted an increase in feed rate from 14,000 bbl./day to 20,000 bbl./day. Octane ratings of the gasoline produced dropped sharply, however, as the reactor temperature was decreased to 865° F. Rather than take this penalty, it was decided to return the temperature to 900° F. after thirty days of total operation. As will be discussed in more detail, the activity of the catalyst had decreased sufficiently by this time to permit a feed rate of 18,000 bbl./day at the higher temperature. Gas-oil conversion varied during this initial 30-day period from a high of about 75%—at the lower feed rates and 900° F.—to a low of 45%—at the higher feed rates and 865° F.

The feed rate of 18,000 bbl./day was the maximum that could be charged to the unit at the 900° F. reactor temperature until the catalyst activity was intentionally decreased, after about 57 days of operation, by dilution with low-activity silica-alumina catalyst. Thereafter, it was possible to increase the feed rate to about 22,000 bbl./day. Operations at this rate were continued until the high-carbon-level method of controlling the activity was initiated. This method of operation is discussed in detail in a subsequent section of this paper.

Maintenance of Catalyst Quality

It has long been recognized that certain characteristics of the catalyst in a commercial cracking unit change with use. During the course of the run described, careful attention was given to catalyst activity and selectivity, physical characteristics, and regeneration characteristics.

Activity and Selectivity. In general, experience has shown that the activity of a cracking catalyst decreases with use. The rate of activity decline for a particular catalyst is dependent on the susceptibility of the catalyst to heat, steam, and poisoning or contamination. Poisoning or contamination that affects the activity of the catalyst can come from the metal or the refractory material of the unit itself or, as is often the case, from the feed stock processed over the catalyst. Even more important than the activity of the cracking catalyst is its selectivity, expressed as carbon factor and gas factor. The carbon factor is, in turn, considered the more important, since it reflects the coke yield in the cracking step. Like the activity, the carbon and gas factors of the catalyst change with use and are affected by heat, steam, and contaminants.

Although catalyst activity is normally less significant than selectivity, it becomes of major importance when it is (a) high enough to cause excessive cracking and thus to limit the amount of feed that can be processed, or (b) low enough that the desired amount of cracking cannot be accomplished at the temperature and space velocity attainable in the reactor.

Pilot-plant evaluations with the high-sulfur charge stock described previously had indicated that silica-magnesia catalyst would have an unusually low rate of activity decline in the commercial unit. During the course of the commercial run, data were obtained that confirmed this prediction. The actual rate of activity decline is shown graphically in Figure 2, where Indiana relative activity is plotted against the age of the catalyst in days on stream. Similar curves are shown for two runs with silica-alumina catalyst in the same type of unit, starting with fresh ground material, and charging a similar feed stock. The run designated *A* utilized fresh ground material for make-up at an average rate of 0.9% of unit inventory per day. During the run designated *B*, fresh catalyst was used for make-up at an average rate of 0.4%/day, except during

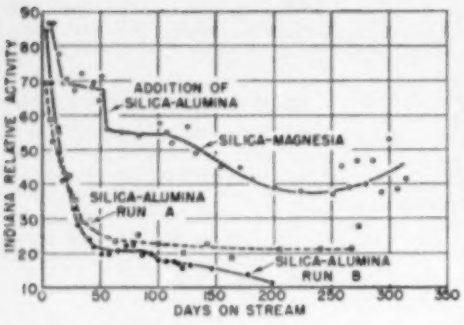

Fig. 2. Indiana Relative Activity vs. Days on Stream.

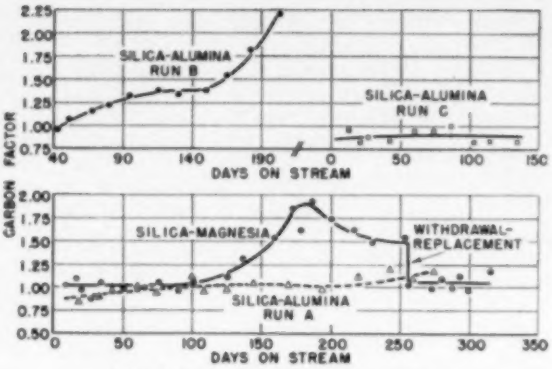

Fig. 3. Carbon Factor vs. Days on Stream.

the period from 15 to 60 days on stream when 20-activity catalyst from run *A* was added at a rate of 1.5%/day. No fresh catalyst was added during the final 34 days of this run. In the silica-magnesia run, the average make-up rate of fresh catalyst was 0.4%/day during the initial 225 days and 1.0%/day thereafter.

On referring to the activity-decline curve for the silica-magnesia run, it will be noted that the activity decreased rather steadily during the initial 20-day period and then appeared to level out between 65 and 70 activity. After about 35 days on stream—when it became apparent that the activity was not decreasing further, and the capacity of the unit was limited by the activity—the catalyst inventory in the unit was diluted with silica-alumina catalyst of relatively low activity from a previous run. The diluted mixture contained 25% silica-alumina. This change reduced the activity to about 54, where it again appeared to level out until about 110 days on stream. At this time the quality of the gas-oil feed stock became definitely inferior to that which had previously been charged, and the catalyst activity decreased over the next 60-day period at a rather rapid rate. This decline has been attributed to the contaminating effects of metals and salts that are known to have been present in the inferior feed stock, and was arrested when the quality of the feed stock was improved. The increase in activity noted after 225 days was the result of large additions of fresh catalyst.

The activity history of the silica-magnesia catalyst described here is considerably different from that of the silica-alumina material. It will be noted from Figure 2 that during run *A* the catalyst activity decreased rapidly during the initial 60 days and then slowly leveled out at about 20. During silica-alumina run *B*, the activity again declined rapidly during the initial 60-day period and then began to level out slightly lower than in run *A*, because of the additions of used catalyst as mentioned previously. Run *B* was carried out during approximately the same period as the silica-magnesia run on a duplicate unit; run *B* started about 40 days before the silica-magnesia run. This is of particular significance since the gas-oil charge stock to both units was identical on the same calendar days. The higher rate of activity decline noted for the latter period of run *B* has been attributed also to contamination by the low-quality feed charged during this interval.

On the basis of these data it appears that, for the particular unit and feed stock employed, and with a 0.4% replacement rate, the silica-magnesia catalyst would have an equilibrium Indiana relative activity of 55-65. This equilibrium activity assumes no dilution with silica-alumina catalyst and use of a relatively noncontaminating feed stock similar to that charged during the initial 100 days of the run. The equilibrium Indiana relative activity for silica-alumina catalyst under the same conditions is about 20.

The rate of change in the carbon factor for the silica-magnesia run is shown in Figure 3 and compared with similar data for silica-alumina runs. Again the data from silica-alumina run *B* are especially significant for comparison purposes, since this run was concurrent with the silica-magnesia run. For purposes of this plot, the run *B* data have been moved forward 40 days to line up the calendar days with the silica-magnesia run. It will be noted that, in general, the silica-magnesia carbon-factor trend is the same as for silica-alumina run *B*, except that the silica-magnesia values are lower. The higher carbon-factor level for silica-alumina run *B* is attributed, at least in part, to the use of relatively large quantities of 1.2 carbon-factor catalyst from run *A* as make-up during the early part of the run. The rapid increase in carbon factor for the two catalysts after about 110 days on stream was due to the contaminating feed stock just mentioned. Run *B* was terminated after 205 days on stream, following which the catalyst was withdrawn and replaced by silica-alumina of satisfactory quality. Before run *C*, the quality of the feed stock was improved, and during this run the silica-alumina catalyst maintained a low carbon factor, as indicated in Figure 3. Data for silica-alumina runs *A* and *C* indicate the general trend in carbon factor that occurs with fresh-catalyst make-up and a relatively clean feed stock containing about 1.5% sulfur.

Physical Characteristics. In following the trends of catalyst quality, it is of interest also to examine the physical characteristics, which include such properties as particle size, aerated density, attrition resistance, and flow behavior. The trend of particle size with time for the silica-magnesia run is illustrated in Figure 4, in which the percentages of material smaller than 40μ, between 40 and 80μ, and larger than 80μ are plotted against the days on stream. The most important observation to be made is that the material smaller than 40μ decreased from approximately 38% to 18% during the 315 days of operation. This trend is in line with usual experience with silica-alumina catalyst. The material smaller than 40μ could well be termed the 20-to-40μ fraction, since only a negligible amount of material smaller than 20μ was found to be present after the

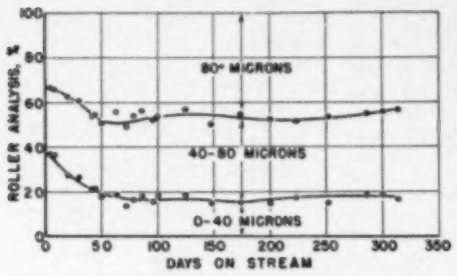

Fig. 4. Silica-Magnesia Particle Size Distribution vs. Days on Stream

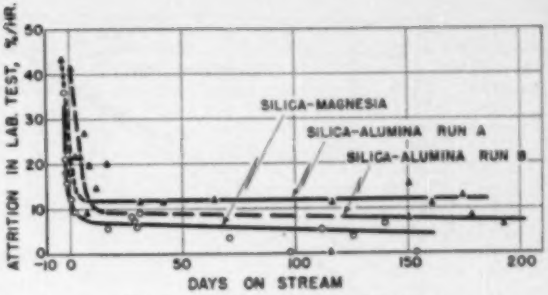

Fig. 5. Attrition vs. Days on Stream.

first few days on stream. This absence of fine particles, which is characteristic of catalytic cracking units without Cottrell precipitators, had been observed in previous runs with other catalysts. The decrease in material smaller than 40μ is seen to be compensated for by approximately equal increases in the 40-to-80μ fraction and in the fraction larger than 80μ. The particle-size distribution of the fresh catalyst additions was similar to that of the sample of commercial catalyst used in the pilot-plant runs and shown in Table 6.

The aerated density, as measured by the differential pressure across a given height in the regenerator, increased from about 29 to 38 lb./cu.ft. during the course of the run. This is a result of the change in particle size shown in Figure 4, together with a gradual increase in density of the individual particles throughout the run, since little variation in the regenerator gas velocity occurred. Although the amount of catalyst holdup above the regenerator grid varied from about 210 to 320 tons during the course of the run, no direct effect on aerated density was observed.

The trend of catalyst attrition with time is plotted in Figure 5. These data were obtained in a laboratory attrition apparatus on samples periodically withdrawn from the commercial unit (*7*); attrition in the laboratory test is expressed as per cent increase in material smaller than 325-mesh over a 1-hr. period. Also included for comparison are data on silica-alumina catalyst obtained during runs *A* and *B*. It is evident that all three catalysts showed the same rapid decrease in attrition rate during the early stages of the run; this decrease is attributed to the rounding off of sharp edges from the catalyst and to the disintegration of weak particles. The silica-magnesia catalyst showed an appreciably lower attrition rate during the entire run. It is believed that this greater resistance to attrition accounts for the smaller losses experienced with this catalyst, as indicated here.

Throughout the operations with silica-magnesia catalyst, the flow properties have been carefully observed. There has been every indication from commercial experience that catalyst circulation has been as uniform or perhaps even more uniform than with silica-alumina catalyst.

Regeneration Characteristics. In addition to the activity, selectivity, and physical properties of the catalyst, the regeneration characteristics during the silica-magnesia run were also closely observed. The pilot-plant data had indicated that fresh and slightly used silica-magnesia catalyst could be regenerated at about the same rate as silica-alumina catalyst; however, it was not known how the catalyst might change in this regard with prolonged use in a commercial unit. One good criterion of the regeneration efficiency of the catalyst in the commercial unit is the carbon content of the regenerated catalyst at a given oxygen content in the flue gas. The trend in the carbon content of the regenerated silica-magnesia catalyst at a flue-gas oxygen content of 1.5% is shown in Figure 6. Similar data plotted for silica-alumina run *B* indicate that no unfavorable trend occurred with time for this catalyst. It can be seen that the carbon content of the silica-magnesia catalyst decreased from 1.0% during the initial 20-day period to a low of 0.5%, and then increased thereafter to 4.0% after 245 days. At this time, the carbon content of the regenerated catalyst was sharply reduced as the result of a program of withdrawal and replacement of catalyst. This program was initiated in order to maintain the unit at cracking capacity, as discussed here.

It is of interest that a noticeable change from 0.9% to 1.2% carbon on regenerated catalyst took place at the time the silica-alumina catalyst was added to the unit to reduce the activity. This effect of the silica-alumina catalyst was also confirmed in pilot-plant experiments, which showed that the addition of low activity silica-alumina to silica-magnesia caused a substantial decrease in regeneration efficiency. In these experiments the regeneration efficiency of a sample of catalyst taken from the plant before dilution with silica-alumina (47 days on stream) was determined in the pilot plant, following which the catalyst was diluted by the addition of approximately 25% of silica-alumina from run *A*. A decrease in regeneration efficiency,

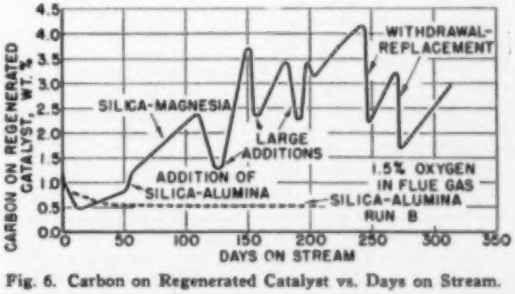

Fig. 6. Carbon on Regenerated Catalyst vs. Days on Stream.

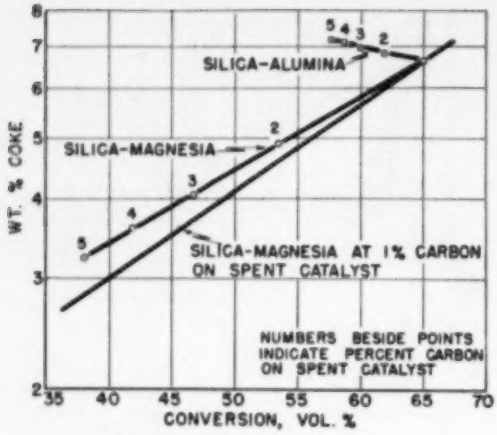

Fig. 7. Coke Yield vs. Conversion.

similar to that noticed in the commercial unit, was observed. In view of this experience, no further dilution was carried out in the commercial unit. Nevertheless, the trend toward increased carbon levels continued until the withdrawal-addition program was started. The run was terminated voluntarily after 315 days on stream because the higher catalyst-addition rate necessary to maintain the unit at capacity could not be economically justified. Further research is being carried out to determine the causes and possible cures for the low regeneration efficiency.

The consequences of this described decrease in the regeneration efficiency of the silica-magnesia catalyst did not limit the operations of the unit until about 200 days on stream. At this time, the carbon content of the regenerated catalyst had built up to 3.5% at 1.5% oxygen in the flue gas. Prior to this time, the activity of the catalyst was too high for optimum operations; however, the high carbon content of the regenerated catalyst effectively reduced the activity to the desired level with little penalty on product distribution, as will be noted. After 200 days on stream, the carbon level was so high that the effective activity of the catalyst decreased below that required to maintain cracking capacity. Although the carbon content of the regenerated catalyst could be reduced by permitting the oxygen content of the flue gas to build up, this technique would cause a loss in capacity due to lower air utilization. Also, when the oxygen content of the flue gas was permitted to increase much above 2.5%, combustion of the carbon monoxide in the flue gas was found to occur. This phenomenon, termed "afterburning," results in overheating of the carbon-steel cyclones and therefore must be avoided.

Catalyst Activity Control by Carbon Level

As indicated, the throughput during commercial operations with silica-magnesia catalyst was limited for some time by the combination of high catalyst activity and the design requirement of a minimum quantity of 50 tons of catalyst in the reaction zone. These limitations made necessary operation at relatively low feed rates and extremely high conversion, which was not desirable. One of the expedients considered for lowering the effective activity of the catalyst in the reactor was increasing the level of carbon on catalyst. Previous experience with silica-alumina catalyst had indicated, however, that such an operation would cause a large increase in coke production, and thus actually result in a loss in throughput. Furthermore, it had been found that, at higher carbon concentrations, uncontrolled coke buildups were likely to occur, which in turn would cause extremely high catalyst losses. Therefore, this expedient was not at first given serious consideration; instead, the catalyst was diluted with low-activity used silica-alumina.

When regeneration became increasingly difficult, and it was apparent that operation at high carbon concentrations on catalyst might be necessary to achieve satisfactory coke-burning rates, a series of pilot-plant tests was carried out on silica-magnesia catalyst to determine quantitatively the effects of carbon level. In these tests the reactor temperature, space velocity, and catalyst-to-oil ratio were kept constant, and the carbon content of the catalyst varied by changing regeneration conditions. The catalyst used in these tests was a sample of silica-magnesia withdrawn from the commercial unit just before dilution with silica-alumina. The feed stock was a sample of the feed to the commercial unit and was approximately as described in Table 7.

Correlated results of these pilot-plant tests are shown in Figure 7, in which coke yield is plotted against conversion, and similar results for silica-alumina catalyst are included for comparison. The lowest line represents a normal coke-conversion line for silica-magnesia catalyst, in which conversion is varied by changing either space velocity or catalyst-to-oil ratio at constant temperature, and carbon on spent catalyst is maintained at 1.0%. For purpose of illustration, the coke yield for silica-alumina catalyst is assumed equal to that of silica-magnesia at 65% conversion. When the carbon on spent catalyst is raised successively to 2, 3, 4, and 5% at constant reaction conditions it is noted that for silica-alumina, the resultant coke yield increases even though the conversion is decreased; hence the uncontrolled coke buildups encountered in commercial operations with silica-alumina. In the case of silica-magnesia catalyst, however, the increased carbon on spent catalyst decreases the effective activity in the reactor to such an extent that conversion is markedly decreased, and the resultant coke yield is also decreased.

The commercial significance of these results is that with silica-magnesia an uncontrolled coke buildup should not occur, since an increase in carbon level tends to reduce the coke production and the two trends tend to offset each other. It was therefore concluded that a commercial trial could be made without fear of carbon on catalyst getting out of control, and this was demonstrated in actual practice. Surprisingly enough, it was also found that operation with as much as 4% C on regenerated catalyst caused no increase in catalyst losses with silica-magnesia. In view of these unpredicted effects of carbon level, this method of activity control was found to be extremely effective, and made it possible to raise throughputs to the desired levels and increase gasoline production. At the same time, the increased carbon level permitted operation of the regenerator with less oxygen in the flue gas, and this partially compensated for the poor regeneration efficiency.

In considering operations at high carbon level, it must be pointed out that the above data do not in any way contradict previous conclusions that higher carbon

on catalyst results in higher coke yield at a given conversion; this is also true for silica-magnesia catalyst, although the effect is not nearly so great as with silica-alumina. For example, if the coke yield at 50% conversion is 4.1% for both catalysts at 1% carbon on spent catalyst, raising the carbon level to 3.0% on silica-alumina catalyst would increase the coke yield to 5.6%, whereas for silica-magnesia the coke yield would only be increased to 4.5%. Hence, there is a slight penalty for operation at high carbon levels even with silica-magnesia. Nevertheless, this method of operation presents an important advantage for silica-magnesia catalyst, since control of carbon is not critical, and an added degree of operational flexibility is thus provided.

Product Distribution and Quality

During the course of the run with silica-magnesia catalyst, daily yield balances were obtained which provided a considerable amount of data for evaluation of the catalyst. Inasmuch as the interpretation of the data obtained during the latter part of the run is complicated by the effects of dilution with silica-alumina—and later by unusual contamination—the operations before dilution have been chosen as being more truly representative of results to be expected with this catalyst. Typical inspection data on the commercial-unit feed stock are shown in Table 7. The feed is shown to be somewhat higher boiling than that used in the original pilot-plant evaluation (Table 4) although the sulfur content is about the same—1.5%. Comparative data on product distribution and quality obtained in the commercial unit are shown in Table 8.

Data are shown for two different charge rates; 25,000 bbl./day and 30,000 bbl./day. In all cases, operations are assumed to be at the coke-burning capacity of the unit, which is 20,000 lb./hr. These feed rates were not actually achieved with silica-magnesia until after dilution; data shown here are based on correlations of actual data obtained at charge rates up to 22,500 bbl./day just prior to dilution. Similar data are also given for silica-alumina catalyst, so that a direct comparison can be made. The Indiana relative activity and carbon factor for the silica-magnesia catalyst were about 70 and 1.0, respectively. The silica-alumina data are based on a catalyst with an activity of 20 and a carbon factor of 1.2.

By referring first to the data at the 25,000-bbl./day charge rate and 900° F. reactor temperature, it can be seen that the silica-magnesia catalyst gave 46.2% gasoline, compared with only 39.0% for the silica-alumina catalyst. This difference in gasoline yield is substantially the same as that predicted from the pilot-plant tests. The expected lower yields of excess butanes and dry gas also appeared for the silica-magnesia operation. Although the coke yield was the same (6.2%) for both operations, the silica-magnesia conversion was 51.0%, compared with 49.8% for silica-alumina. The difference here indicates a slightly more favorable coke-conversion relationship for the silica-magnesia catalyst.

The octane data are of particular interest. The silica-magnesia catalyst gave a lower-octane gasoline than did the silica-alumina catalyst. On the motor basis, the difference was 1.6 units; on the research basis, the difference was 5.1 units. Data are also shown for a silica-magnesia operation at 25,000 bbl./day and 925° F. reactor temperature, chiefly to indicate the effect of temperature on the octane number of the gasoline. At 925° F. with silica-magnesia, the motor octane rating of the gasoline was only 0.6 units lower than with silica-alumina; the research octane ratings were 4.0 units apart, whereas at 900° F. the difference was 5.1 units.

An interesting comparison of operations at a charge rate of 30,000 bbl./day is also shown in Table 8. For this purpose silica-magnesia operation at 925° F. is compared with silica-alumina operation at 900° F. For the particular unit employed in these tests, operation with silica-alumina catalyst at temperatures above 900° F. is not practical at a 30,000-bbl./day charge rate and at maximum coke-burning capacity because the high yields of butanes and dry gas would overload the fractionator. The gasoline yield for the silica-magnesia catalyst was 40.2%, compared with 36.6% for the silica-alumina catalyst. The dry-gas yield was less for the silica-magnesia catalyst (5.9 vs 6.5%), even though the reactor temperature was 25° F. higher. The octane ratings show about the same differences at this throughput as in the 25,000-bbl./day cases. The clear motor and research ratings are respectively 0.5 and 4.1 units higher for the silica-alumina catalyst.

It should be emphasized that the above silica-magnesia data are based on the commercial operations before dilution with silica-alumina catalyst. Also, no penalty has been assessed against the silica-magnesia data for the poor regeneration characteristics that developed during the course of the run.

Catalyst Make-up Requirements

In the operation of a commercial fluid catalytic cracking unit, one of the more substantial daily operating costs arises from the catalyst make-up necessary to maintain constant levels in the unit. With silica-magnesia catalyst, the make-up requirements during the initial 225 days averaged 2 tons/day. Under the same conditions of operation, the make-up rate with silica-alumina has been found to be 3 tons/day. Since the variables known to have a direct effect on catalyst loss rate, namely catalyst particle size, regenerator gas velocity, and cyclone dipleg seal, were the same in both cases, it is believed that the lower make-up rate for the silica-magnesia catalyst is due to the higher attrition resistance, as shown in Figure 5.

It was especially significant in the silica-magnesia run that no effect on catalyst losses could be ascribed to the high carbon content of the catalyst in the system, even when the carbon level of the regenerated catalyst was as high as 4.0%.

Conclusions

Based on 315 days of commercial operation with silica-magnesia catalyst, the following conclusions have been drawn:

1. Higher gasoline yields of lower octane number are obtained with this catalyst than with silica-alumina catalyst under comparable operating conditions. Results check closely the predictions based on exploratory and pilot-plant evaluations.

2. Unusually good maintenance of activity is experienced with this catalyst, compared with silica-alumina. Maintenance of selectivity is at least as good as for silica-alumina.

3. The make-up requirement is only about two thirds of that normally used in similar operations with silica-alumina, primarily because of the higher attrition resistance of silica-magnesia.

4. It is possible to operate with high carbon on catalyst, without the uncontrolled coke buildups and excessive catalyst losses which are experienced with silica-alumina catalyst. Such operations have given added flexibility in control of cracking severity without major effect on product distribution.

5. An unfavorable trend toward decreased efficiency of regeneration was observed, which required relatively high catalyst-makeup rates to maintain cracking capacity. Additional research is required to determine the causes and possible cures for the low regeneration efficiency.

Acknowledgment

The authors wish to acknowledge the work of many associates in the research department of the Standard Oil Co. (Ind.) who carried out the experimental work and assisted in correlation of the data. The cooperation of the manufacturing department during this plant-scale trial is also greatly appreciated.

Literature Cited

1. Anderson, N. K., and Sterba, M. J., *Oil Gas J.*, **44**, No. 33, 77 (1945). *Petroleum World* (Los Angeles), **43**, No. 3, 54 (1946).
2. Bailie, J. C., and See, M. J., U. S. Patents 2,343,371 (March 7, 1944), 2,343,295 (March 7, 1944), and 2,378,530 (June 19, 1945).
3. Brunauer, S., Emmett, P. H., and Teller, E., *J. Am. Chem. Soc.*, **60**, 309 (1938).
4. Conn, A. L., and Brackin, C. W., *Ind. Eng. Chem.*, **41**, 1717 (1949).
5. Davidson, R. C., *Petroleum Refiner*, **26**, 663 (1947).
6. Evans, L. P., *Oil Gas J.*, **44**, No. 47, 167 (1946).
7. Forsythe, W. L., Jr., and Hertwig, W. R., *Ind. Eng. Chem.*, **41**, 1200 (1949).
8. Murphree, E. V., Brown, C. L., Gohr, E. J., Jahnig, C. E., Martin, H. Z., and Tyson, C. W., *Trans. Am. Inst. Chem. Engrs.*, **41**, 19 (1945).
9. Richardson, R. W., Johnson, F. B., and Robbins, L. V., Jr., *Ind. Eng. Chem.*, **41**, 1729 (1949).
10. Shankland, R. V., and Schmitkons, G. E., *Proc. Am. Petroleum Inst.*, **27**, III, 57 (1947).
11. Webb, G. M., and Ehrhardt, C. H., *Petroleum Processing*, **2**, No. 1, 7 (1947).

Discussion

M. J. Sterba (Universal Oil Products Co.): We think that the Standard Oil Company of Indiana should be congratulated for having been the first to test silica-magnesia cracking catalyst in full-scale operation, confirming some of the virtues attributed to silica-magnesia catalyst in a small-scale work; also, for showing up what might be the only bad feature of the catalyst—its somewhat difficult regeneration characteristics as reckoned by the dynamic relationship between oxygen concentration in the flue gas and carbon concentration on the regenerated catalyst.

We have had a particular batch of silica-magnesia catalyst in pilot-plant service for 3,000 hr. That is a great deal shorter period than indicated on the slides here, and the change in regeneration efficiency over this period again as reckoned by the relationship between oxygen concentration and flue gas and carbon content of the regenerated catalyst was very slight. The increase in carbon content was from 0.2% to only 0.35% for a particular oxygen concentration. Therefore, this pilot-plant experience would not have predicted the regeneration features indicated by Mr. Meehan on his slides.

In several instances of commercial operation, an observed decreased regeneration efficiency has been traced to partial distribution grid failure. We should like to ask the authors if it is certain that the regenerator distribution grid has remained intact during the run.

It would be of interest to have the authors tell us how the carbon dioxide to carbon monoxide ratios from silica-magnesia compare with the ratios from silica-alumina and natural catalysts used in identical commercial units, and if there has been a trend of variations in the carbon dioxide to carbon monoxide ratio with time.

Also can the regenerated catalyst containing approximately 3% C be burned clean, either in the commercial unit, in the pilot plant with air, or in laboratory equipment with pure oxygen? We have had one instance of silica-magnesia catalyst becoming carbonized and highly overheated for a short time, after which carbon could not be burned off either in the unit or in the laboratory.

W. F. Meehan: The unit is still continuing on stream, and therefore, we have no firm conclusions as to whether the regenerator grid is intact or not, but since the unit is very susceptible to fresh catalyst additions, and is operating smoothly, we have reason to believe the regenerator grid is probably in good shape.

As regards the carbon dioxide to carbon monoxide ratio in the flue gas with silica-magnesia, it has been very constant between 1.6 and 1.7. In these units with silica-alumina catalyst and noncontaminated feed stocks, we get just about the same thing; 1.6 to 1.7. This is somewhat higher than is ordinarily obtained with silica-alumina in other units. With natural catalyst, the ratio was more like 2 to 2½.

We have taken samples of the catalyst with high carbons, about 3%, and have burned it clean in the laboratory; burned it down to essentially no carbon. It does burn down with time. It also has been burned down clean in the pilot plant, and thereafter a cracking test has been run on the catalyst after it had been burned clean, and the regeneration problem was still there. It just will not regenerate, even if it has been burned clean.

George Liedholm (Shell Development Co.): Even after exhaustive tests were made on the catalyst in the pilot plant before it was charged to the commercial unit, there are still problems that may develop in commercial operation. We can't entirely, therefore, rely upon small-scale testing. I think the Indiana people are to be commended on their pioneering work in silica-magnesia catalyst. I think Mr. Sterba's explanation of the difficulties they are having in Indiana may be a reasonable one.

There is another possible explanation, that the type of carbon that is laid down on this particular batch of commercial silica-magnesia catalyst, may be a little different animal from the carbon that lays down on silica-alumina catalyst. Instead of spreading out on the surfaces of the catalyst, this carbon may be simply pumping down in the pores, as a nonporous type of carbon, quite unavailable to the oxygen. I noted from the paper that the pore diameter for this batch of silica-magnesia catalyst was about 30 Angstrom units compared with 40 to 50 for silica-alumina. The pore diameter does not increase as time goes on, and furthermore, this type of catalyst has a tendency to absorb a large amount of oil which is extremely difficult to remove by stripping, but which can be extracted with a solvent.

Now those points may lend some credence to the fact that the mechanism of carbon laydown, that is, the form of the carbon that is laid down may simply be the form that is harder to get at.

Have the authors any information as to the ash content of the feed, and the ash concentration, that is, the concentration of the components of the ash on the catalyst which were responsible, let's say, for the increase in carbon yield with time.

W. F. Meehan: We definitely do believe that a different type of carbon is being laid down on the catalyst. For instance, we've determined that carbides are present and are developing theories based on the different types of carbon being laid down on the catalyst.

As regards the contaminants on the catalyst, unfortunately I don't have any of those numbers or analyses in mind. However, we have obtained analyses of the contaminants. Of course, there is vanadium and nickel and sodium, etc. A. L. Conn might have in mind some of the quantitative numbers.

A. L. Conn (Standard Oil Company, Indiana): Although I do not recall the actual numbers, it was established that at 110 days on stream, when the feed appeared to be of inferior quality, there was an increase in metals concentration and also an increase in salts. A rather exhaustive study of the various feed components was then instituted. Since a large number of tanks in the refinery are pumped directly into the catalytic cracking feed tanks, it is quite a job segregating all the stocks. Some components were finally found which were high in metal and salt content, and when these were removed, an improvement in carbon factor was observed. We have not been able to establish a relationship, however, between metals contamination and regeneration characteristics.

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LIMITING FLOWS IN PACKED EXTRACTION COLUMNS

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LIQUID-liquid extraction in packed columns ordinarily involves the countercurrent flow of two immiscible liquid phases through the packing. Flow occurs as a result of gravitational forces due to a difference in density between the two phases. One phase, denoted as the "continuous phase," fills the voids in the packing and flows through the column in a continuous manner. The second phase, "discontinuous phase," is subdivided into small globules by a suitable distributor and passes through the continuous phase and the interstices of the packing in the form of individual globules or droplets. Either phase may be made discontinuous by proper distributor design and location.

For a given flow rate of one phase in a given column there will be some maximum flow rate of the other phase, which if exceeded will result in accumulation of one of the phases in the column and cause ultimate failure of column operation. This limiting flow condition is a function of the particular liquid system and packing under consideration. A knowledge of limiting flows, or flooding velocities, is essential to the proper design of extraction columns. Unfortunately this subject has received little attention in the literature so that few data and no general correlations are presently available for prediction of column capacity.

Blanding and Elgin (*2*) made a comprehensive study of the effects of entrance and distributor design on flooding velocities in various packings, and pointed out that these factors may be limiting unless proper precautions are observed. Data were reported for flow of several liquid pairs in ½-in. Raschig rings, ½-in. Berl saddles and ½-in. clay spheres. A few scattered observations of flooding have also been made incidental to other investigations (*1, 7-8*).

In the present study special attention was directed toward the effects of physical properties of the flowing fluids on limiting flows. The effect of interfacial tension was specially studied. Most of the experiments were conducted with ¼-in. carbon Raschig rings to extend the range of packing characteristics covered by available data. Few data were obtained with ½-in. Berl saddles for comparison with previous studies. Finally, an attempt was made to generalize the data of the present investigation with that of previous work in the form of a general correlation useful for extraction column design.

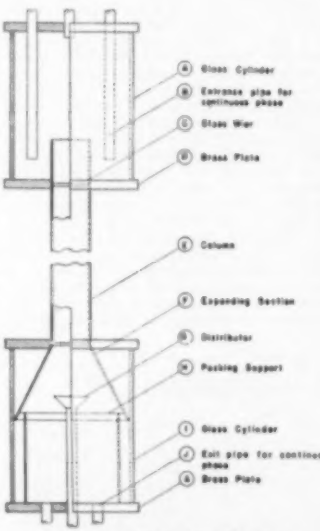

Fig. 1. Extraction Column.

Experimental

Apparatus. The column was constructed similar to the type described by Blanding and Elgin (*2*). It is shown diagrammatically in Figure 1. The main section was constructed from pyrex tubing, 2.6 in. I.D. and 4 ft. in length. End sections were glass cylinders 9 in. I.D. and 11.5 in. high. The end sections were attached to the column by means of flat brass plates and tie rods. Compression gaskets were fitted between the brass plates and and the glass. During all runs the liquid interface was maintained in the enlarged upper end section at a position approximately 3 in. below the top of this section. The continuous phase was introduced into the column through two pipes extending into the annular space between the upper 9-in. glass cylinder and a small weir of the same diameter as the column, which acted as a 3-in. extension of the column proper into the end section. This arrangement functioned satisfactorily and no interference was observed between the entering continuous phase and the rising drops of the discontinuous phase.

The bottom end section was also similar to the type described by Blanding and Elgin. An inverted funnel was used as a gradual expander. It was 5½ in. high, tapering from a 2.6 in. I.D. at the upper end to 8.5 in. I.D. at the lower end.

Three different locations of the packing support were tested for satisfactory operation as follows: (1) with the packing sup-

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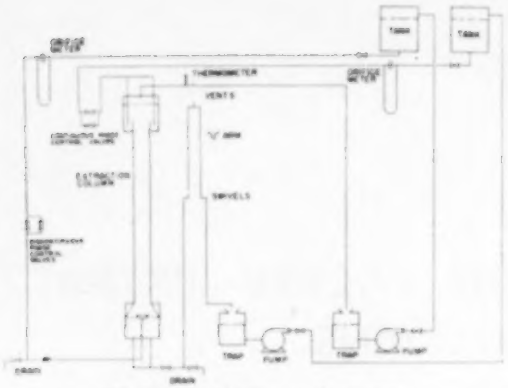


Fig. 2. Flow Diagram of Apparatus.

port located below the column at the top of the expanding entrance section the column functioned fairly satisfactorily, except that it was impossible to avoid some reduction in free cross section in order to give the packing support sufficient mechanical strength and rigidity; (*2*) with the packing support located ½ in. above the distributor near the lower end of the expanding section the discontinuous phase would not pass through the packing support and operation was unsatisfactory at all flow rates; (*3*) location of the packing support 1.25 in. below the distributor as indicated in Figure 1 gave most satisfactory operation and reproducible results under all flow conditions. This location was accordingly adopted for all data reported in this paper.

The distributor consisted of an inverted oil can base, 2.75 in. in diameter with 50 holes of 0.1015 in. diameter drilled in the bottom. In view of the observations of Blanding and Elgin (*2*) that flooding velocities are essentially independent of the size of the holes in the distributor no other distributor arrangement was used in this work.

Equipment Layout and Flow. A schematic diagram of the column and related equipment is shown in Figure 2. The effective pressure drop of the continuous phase through the column was controlled by means of an inverted "U" arm, vented at the top, and swiveled so that the height of the vent could be adjusted. This "U" arm also controlled the position of the interface in the upper end section.

The two liquids were fed to the column under essentially constant head from tanks attached to the ceiling of the laboratory. One-half inch standard pipe was used throughout except for a section of 1-in. pipe leading from the discontinuous phase tank to the orifice meter.

The flow rates of the two phases were measured with calibrated orifices, and 36-in. manometers. Various orifice plates, calibrated in place, were used, depending on the flow rate required.

Delicate control of the flow rates was obtained by using a ½-in. gate valve, for rough adjustments, and paralleling it with a ¼-in. needle valve for fine adjustments. This arrangement worked well, and gave good control even at low flow rates. The two phases, after passing through the column, were collected in 5-gal. tanks and were periodically recirculated back to the storage tanks at the ceiling with two small centrifugal pumps.

Packing Materials. Two types of packing materials were used: ¼-in. carbon Raschig rings, manufactured by the National Carbon Co., and ½-in. porcelain Berl saddles manufactured by Maurice A. Knight. The packing was sorted for removal of irregular and broken pieces before packing the column. The column was filled with water and the packing material dumped in the top, slowly and at random, to a height of 39 in. The packing was not shaken or tamped. The ¼-in. rings showed a light tendency to become gradually more densely packed. However, the change in height of the packing was less than ½-in. during the total period of use and the effect on the column performance was negligible. This instability was not observed with the ½-in. saddles. The fractional void measurements were made in a glass cylinder of diameter equal to that of the column, and the packing was dumped in the same manner for these measurements. The surface area of the Raschig rings was calculated from average measured dimensions of a representative number of rings. The surface area of the Berl saddles was calculated from the manufacturer's data. Details of the packing characteristics are listed in Table 1.

Liquid Materials. In the course of this study eight systems were investigated; seven combinations of liquids in ¼-in. Raschig rings and one pair of liquids in ½-in. Berl saddles. Systems and properties of the liquids used are given in Table 2. Numerous runs were made with a heavy straight run, low sulfur gasoline as the discontinuous phase. Small amounts of *n*-butyl alcohol were added to the gasoline-water system, and allowed to distribute to the equilibrium concentration in each phase, independently to vary the interfacial tension with negligible change in any of the other properties of the system. Other liquids employed were Berkeley tap water, and technical grade methyl *i*-butyl ketone, glycerol, carbon tetrachloride, and toluene. Measurement of liquid properties is described in a later section.

Operating Procedure. The procedure in making a run was first to set the flow rate of one of the phases, usually the continuous phase. The flow rate of the discontinuous phase next was gradually increased until the flooding point was reached. In a few runs, when the velocity of the discontinuous phase was high the procedure was reversed by first establishing the flow rate of the discontinuous phase followed by a gradual increase of the flow rate of the continuous phase. There was no apparent difference in the flooding points for the two methods in the range of water-organic liquid ratios investigated. In all cases the height of the interface in the upper disengaging section was maintained carefully at a constant level.

The flooding point was indicated by the appearance of a thin layer of the discontinuous phase below the packing support. The flow rates at the time of the first appearance of this layer were taken as the flooding conditions. As operation continued at the flooding point, this layer of discontinuous phase slowly increased in thickness. This visual determination of flooding was found to be reproducible and easy to observe. An attempt was made to relate the pressure drop of the continuous phase to the flooding point, but, no consistent relationship could be established. The difficulty may have been due to the effect of changes in column holdup and resulting change in the apparent density of the total liquid contents of the column.

Measurements. An exception to the procedure of measuring the flow rates with calibrated orifice meters was made for the runs with carbon tetrachloride as the continuous phase. In this case the flow rates were measured by taking time-weight readings of the carbon tetrachloride flowing out of the column. Runs and measurements were all made at room temperature which varied from 19° C. to 25° C. After each run the density of each phase was measured with a Westphal Balance. The interfacial tension was measured after each run using the drop weight-volume described by Harkins (*6*). Viscosities of all materials were measured with an Ostwaldt-type viscosimeter.

Results

Experimental data are summarized in Table 3. Data are expressed in terms of the superficial linear velocity of each phase at the flooding point, U_c and U_d, based on the total column cross section.

TABLE 1.—DATA ON PACKING CHARACTERISTICS

Series	Packing Material	a, sq.ft./cu.ft.	F,
1–7	¼ in. Carbon Raschig Rings	208	.534
8	½-in. Porcelain Berl Saddles	120*	.695
9–12	½ in. Porcelain Berl Saddles (*8*)	110	.75
13–14	¼ in. Carbon Raschig Rings (*8*)	114	.74
15–16	¼-in. Clay Spheres (*6*)	72	.50
17	½-in. Porcelain Raschig Rings (*7*)	105*	.644
18	½-in. Porcelain Berl Saddles (*7*)	120*	.694

* Based on manufacturer's data.

TABLE 2.—PROPERTIES OF SYSTEMS

Series	Continuous Phase	Discontinuous Phase	Packing	μ_c cp.	μ_d cp.	ρ_c lb./cu.ft.	ρ_d cu./cu.ft.	$\Delta\rho$ lb./cu.ft.	σ dynes/cm.
1	Water	Gasoline	¼-in. Rings	0.94	0.92	62.4	50.4	11.9	37.6
2	Water	Gasoline	¼-in. Rings	0.97	0.92	62.4	49.8	12.6	39.6
3	Water	Gasoline	¼-in. Rings	0.96	0.92	62.4	49.8	12.6	20.6
4	Water	Gasoline	¼-in. Rings	0.98	0.92	62.4	49.8	12.6	8.9
5	Water	M. I. K.	¼-in. Rings	0.92	0.58	62.4	50.9	12.4	11.4
6	35% Glycerol	Toluene	¼-in. Rings	2.77	0.89	67.8	53.5	14.3	24.1
7	CCl_4	Water	¼-in. Rings	0.92	0.92	99.6	62.4	37.3	53.8
8	Water	Gasoline	½-in. Saddles	0.92	0.92	62.4	49.8	12.6	37.0
9	Water	M. I. K.	½-in. Saddles	0.96	0.58	62.4	49.5	12.9	11.4
10	Water	Naphtha	½-in. Saddles	0.98	0.62	62.4	53.0	9.4	36.0
11	M. I. K.	Water	½-in. Saddles	0.58	0.96	49.5	62.4	12.9	11.4
12	Naphtha	Water	½-in. Saddles	0.62	0.98	53.0	62.4	9.4	36.0
13	Water	Naphtha	½-in. Rings	0.96	0.62	62.4	53.0	9.4	36.0
14	Naphtha	Water	½-in. Rings	0.62	0.98	53.0	62.4	9.4	36.0
15	Water	M. I. K.	½-in. Spheres	0.98	0.58	62.4	49.5	12.9	11.4
16	Naphtha	Water	½-in. Spheres	0.62	0.98	53.0	62.4	9.4	36.0
17	Water	Toluene	½-in. Rings	0.96	0.89	62.4	54.0	8.4	36.0
18	Water	Toluene	½-in. Saddles	0.96	0.89	62.4	54.0	8.4	36.0

Plots of $U_c^{1/2}$ vs. $U_d^{1/2}$ for the ¼-in. cylinders are shown in Figure 3. The linear relation between the square roots of the continuous and discontinuous phase velocities is in agreement with the previous observations of Blanding and Elgin on ½-in. packings, and the results of the present study for ½-in. Berl saddles.

In addition to the data of this investigation data of Blanding and Elgin were taken from their published curves (*2*). Representative points over a range of flow rates were selected from these curves for each series of runs. These data are given in Table 4, and with the data of Table 3 constitute the data used in the development of the correlations to follow.

On the basis of the Series numbers given in Tables 3 and 4 the physical properties of the liquids and characteristics of the packings may be determined by reference to Tables 1 and 2. Physical properties of the fluids used by Blanding and Elgin which were not given in their paper were taken from the International Critical Tables or measured directly on similar materials.

TABLE 3.—EXPERIMENTAL DATA

Series	Run	U_c ft./hr.	U_d ft./hr.	$U_c^{1/2}+U_d^{1/2}$
1	8	28.1	13.0	8.91
1	9	29.5	13.7	9.13
1	14	32.3	9.7	8.80
1	16	20.4	11.6	8.56
1	17	28.2	13.7	9.02
1	18	23.4	16.3	8.89
1	19	21.2	18.1	8.86
1	22	22.0	16.7	8.80
1	23	19.1	22.2	9.08
1	25	13.9	25.8	9.08
1	26	15.1	26.1	9.00
1	27	20.5	20.1	9.01
1	28	9.5	28.2	9.20
1	29	17.9	22.8	9.01
1	31	28.1	11.6	8.72
1	34	13.6	32.7	9.14
1	35	24.2	8.0	8.69
1	32	24.0	8.0	8.69
2	36	24.0	22.4	9.63
2	37	30.3	18.6	9.81
2	38	23.9	23.4	9.73
2	39	23.9	23.4	9.73
2	40	30.5	19.0	9.89
2	41	16.4	35.8	10.06
2	42	16.2	35.8	10.03
2	43	30.4	6.6	9.68
2	44	41.2	7.9	9.24
2	45	41.2	8.2	9.29
2	46	30.4	14.6	9.34
2	47	30.4	14.7	9.34
2	48	24.4	18.6	9.26
2	49	30.4	15.5	9.46
3	51	19.4	30.5	10.05
3	52	36.4	12.4	9.58
3	53	41.1	9.0	9.44
3	54	26.0	19.0	9.48
3	55	14.8	33.9	9.70
3	56	25.4	19.4	9.47
4	57	33.7	22.8	10.58
4	58	39.2	15.6	10.23
5	63	45.2	16.4	10.80
5	64	33.7	24.0	10.72
5	65	27.8	29.6	10.69
5	66	54.0	9.0	10.39
5	67	49.4	11.6	10.45
5	68	36.6	19.1	10.42
5	69	22.5	35.2	10.82
5	70	20.3	29.4	10.80
6	71	19.7	15.8	8.43
6	72	26.8	12.4	8.71
6	73	31.0	8.2	8.45
6	74	17.4	20.8	8.76
6	75	9.9	33.4	8.89
7	83	74.5	44.4	15.48
7	84	84.3	44.1	15.74
7	85	76.0	53.4	16.03
7	86	119.6	25.7	15.95
7	87	98.5	39.6	15.24
8	88	98.5	31.2	15.54
8	89	52.0	72.5	15.73
8	90	145.7	15.1	15.92
8	91	57.0	70.1	15.91
8	92	143.2	14.6	16.06
8	93	87.0	45.0	16.06

Flow Characteristics. In the runs made with the ¼-in. Raschig rings the packing material was so dense that it was impossible to make conclusive observations as to the behavior of the two phases inside the packing. It was observed that the drops of discontinuous phase issued from the top of the packing at only a few different places. Drops issued from these places in rapid succession. From time to time these discharge points on the top of the packing would change. This observation seemed to indicate that only a small portion of the packing was actually being used in flow. This situation was not changed when the packing was removed and repacked. The discontinuous phase appeared to pass up through the packing as a group of small, irregular-shaped globules, moving with an irregular, unsteady motion. In general, the continuous phase appeared to wet the packing, irrespective of the liquid or packing material used. However, in the carbon

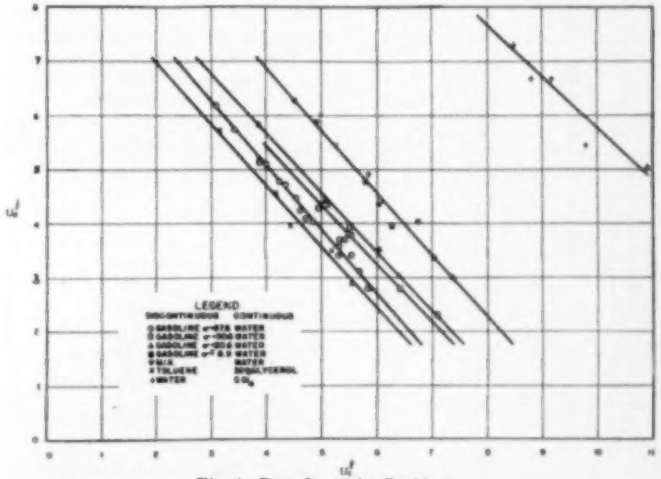


Fig. 3. Data for ¼-in. Packings.

tetrachloride-water system, the discontinuous water phase appeared to have some tendency to wet the packing and a marked tendency to wet the glass walls of the column. Below the flooding point drops of water were observed rising through the continuous carbon tetrachloride phase, but at the flooding point, particularly at the base of the column, the originally discontinuous water phase became continuous, and drops of carbon tetrachloride passed down through the water.

With the column packed with ½-in. Berl saddles it was possible to observe more easily the flow in the column. The discontinuous phase consisted of streams of drops of apparently constant size; the shape was more nearly spherical in this packing than with the ¼-in. rings. These streams of distinct drops worked their way up through the column, the drops deforming where necessary to pass through the interstices in the packing. As the flooding point was reached the holdup of the discontinuous phase, gasoline in this case, was markedly increased, and there was a slight tendency for the gasoline drops to enlarge. The drops became very closely packed but they were still distinguishable as drops. This observation is in disagreement with the views of Blanding and Elgin (*2*) who state that both phases become continuous at the flooding point. Some preferential flow of the discontinuous phase along the wall of the column appeared to occur with this packing. It was not possible to determine the seriousness of this wall effect. With the gasoline-water to which had been added 6.5% *n*-butyl alcohol giving an interfacial tension of 8.9 dynes/cm., the operation of the column was not reproducible. In this case the drop size was not constant. There was a tendency to form many small droplets (approx. 2-mm. diameter) in the packing. However, the number of these small droplets was not constant, and depended on the past history of the column. It is believed that the *n*-butyl alcohol had some effect, as yet unexplained, which made operation of the column unsatisfactory. Consequently these data were not weighted heavily in the development of the correlations. Data for two of these runs are given in Figure 3. No corresponding difficulty was experienced with the low interfacial tension methyl isobutylketone-water system.

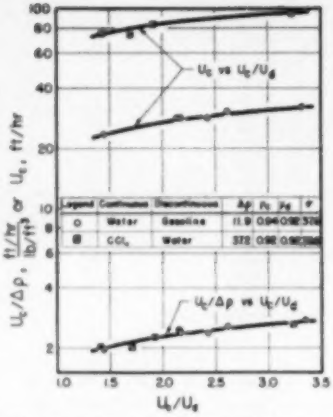


Fig. 4. Effect of Density Difference.

TABLE 4.—DATA (*2*)

Series	U_c, ft./hr.	U_d, ft./hr.	$U_c^{1/2}+U_d^{1/2}$
9	144	58	19.5
9	79	100	19.5
9	36	184	19.4
9	196	31	19.6
9	100	90	19.5
9	64	132	19.5
9	56	144	19.5
9	244	16	19.6
10	22	100	14.8
10	64	48	14.8
10	100	25	15.0
10	144	9	15.0
10	121	16	15.0
10	79	36	14.9
10	49	63	14.8
10	36	78	14.7
10	16	115	14.7
11	289	16	21.0
11	256	25	21.0
11	225	35	21.9
11	196	48	20.9
11	169	63	20.9
11	144	79	20.9
11	121	97	20.9
11	100	117	20.8
11	81	139	20.8
11	64	164	20.8
11	49	190	20.8
12	25	112	15.6
12	36	87	15.4
12	49	64	15.0
12	64	45	14.7
12	81	29	14.4
13	28	81	14.3
13	61	36	13.8
13	81	21	13.6
13	100	12	13.4
14	102	14	13.8
14	64	36	14.0
14	49	49	14.0
14	30	77	14.2
15	138	9	14.7
15	115	16	14.7
15	95	25	14.7
15	78	16	14.7
15	49	60	14.7
16	16	74	12.6
16	36	46	12.8
16	64	27	13.1
16	81	19	13.3
16	100	12	13.4

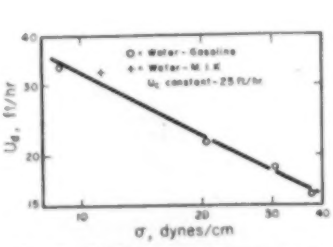


Fig. 5. Variation of Discontinuous Phase Flow with Interfacial Tension.

Effect of Liquid Properties

For any series of runs in a given packing and with a given pair of liquids the continuous phase velocity is a unique smooth function of the velocity ratio, U_c/U_d. The objective in the development of a general correlation was to find suitable relations between the variables so that these curves for all the runs may be superimposed into a single curve. The approach necessarily was largely empirical in the absence of any quantitative mathematical theory for flow in such systems. In a qualitative manner, certain variables would be expected to have a significant effect on the limiting flows and these variables have been introduced as discussed here. It is hoped that a more fundamental theoretical approach to this problem can be made in the future.

Units. The units used for all variables throughout the paper are consistent with those given in the notation section.

Effect of Density. Since density difference between the phases and resulting gravitational forces constitute the primary potential causing flow, it would be expected by analogy to Stokes law for viscous flow conditions that at a constant ratio of U_c/U_d the limiting velocity of the continuous phase, and also the discontinuous phase, would vary as the first power of the density difference provided the drop size of the discontinuous phase remained constant. This relationship has been suggested by Colburn (*3*). The upper curves of Figure 4 show curves of U_c vs. U_c/U_d for water-gasoline and carbon tetrachloride-water in ¼-in. Raschig rings. Separation of these curves should be almost entirely due to density effects since the other physical properties of the liquids are essentially equal. As shown in the lower curve of Figure 4, dividing the continuous phase velocity by the density difference brings the two upper curves together into a single function. Since the density difference is changed more than threefold in these runs the results are

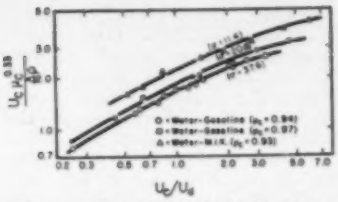


Fig. 6. Effect of Interfacial Tension.

rather conclusive. However, further experimentation would be desirable to test these conclusions under more stringent conditions.

Effect of Interfacial Tension. Blanding and Elgin (*2*) and Goss (*5*) previously suggested that some surface tension effect may influence the flooding velocities in packed columns.

Figure 5 shows results obtained for gasoline-water systems with small quantities of butyl alcohol added to lower the interfacial tension. These data were obtained from the smoothed curves of the data plotted in Figure 3. At a constant continuous phase velocity (water continuous) of 25 ft./hr. the discontinuous phase velocity varies inversely with approximately the ½ power of the interfacial tension over a range of interfacial tensions from 37.6 to 8.9 dynes/cm.; also the corresponding data for the water-M.I.K. system falls in approximately with the water-gasoline data. The principal difference between these two systems is the discontinuous phase viscosity, so that the results indicate that in this range of viscosities the effect of discontinuous phase viscosity is probably not large. This is further substantiated in the correlations developed later.

Data for three systems of different interfacial tension are shown in Figure 6 to show the effect of interfacial tension on the curves of U_c vs. U_c/U_d. The effects of slight differences in continuous phase viscosity and $\Delta\rho$ have been accounted for as shown, although in this case these effects are so small they could have been neglected without appreciably changing the relative positions of the curves. Multiplying the ordinate $U_c\mu_c^{0.33}/\Delta\rho$ by $\sigma^{0.24}$ brought the curves of Figure 6 together into a single function. It should be pointed out that the effect of continuous phase viscosity has been anticipated at this point in order to improve the accuracy in developing the exponent on the interfacial tension. The single curve obtained for the water-gasoline and water-M.I.K. data by introduction of $\sigma^{0.24}$ is shown in the upper curve of Figure 7; in this case the continuous phase viscosities are essentially equal.

The mechanism by which interfacial tension influences the flooding velocity cannot be determined in this empirical manner. It would be expected that a low interfacial tension would favor the development of smaller droplets of the discontinuous phase and hence facilitate their passage through the interstices of the packing. However, no significant variation in drop size with interfacial tension was visually observed, except with the water-gasoline system at 8.9 dynes/cm. as noted previously. It would also be expected that the droplets would deform more readily with low interfacial tension and thus encounter less resistance in passage through the packing. This view is plausible, although the apparent failure of discontinuous phase viscosity to affect the flow is at variance with a hypothesis based on drop deformation. A third possibility may be that a low interfacial tension favors the discontinuous phase droplet's breaking away from points of rest within the packing.

Effect of Viscosity. Viscosity of the continuous phase would be expected to influence the rate of rise of the discontinuous phase droplets on the basis of Stokes law, although the viscosity need not enter to the first power if factors in addition to viscous drag contribute appreciably to the resistance to flow. Having determined the effects of density difference and interfacial tension it is

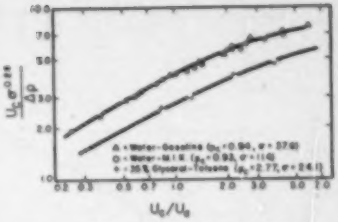
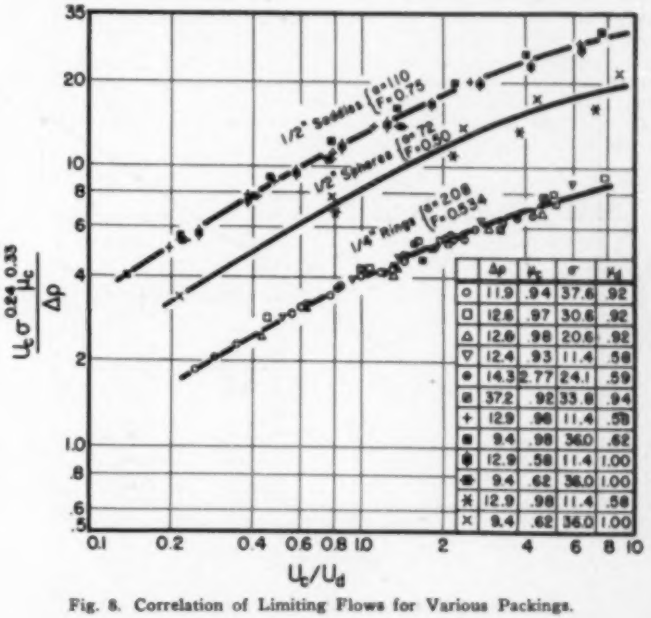


Fig. 7. Effect of Continuous Phase Viscosity.

possible to separate the effect of continuous phase viscosity. Curves for water-gasoline, and water-M.I.K. (continuous phase viscosity approximately 0.94) and 35% glycerol-toluene (continuous phase viscosity 2.77) are shown in Figure 7. It is apparent that a high continuous phase viscosity causes a decrease in U_c and column capacity. Multiplying the ordinate $U_c\sigma^{0.24}/\Delta\rho$ by the continuous phase viscosity to the 0.33 power brought the curves of Figure 7 together into a single function. A conclusion of practical interest is, that other factors being equal, the phase having the highest viscosity should be made discontinuous.

General Correlation. In the foregoing sections the effect of each variable has been systematically isolated by graphical curve fitting. These results indicate that



	Δρ	μ_c	σ	μ_d
○	11.9	.94	37.6	.92
□	12.6	.97	30.6	.92
△	12.0	.98	20.6	.92
▽	12.4	.93	11.4	.58
●	14.3	2.77	24.1	.59
■	37.2	.92	33.8	.94
+	12.9	.98	11.4	.58
■	9.4	.98	36.0	.62
◆	12.9	.58	11.4	1.00
◆	9.4	.62	36.0	1.00
*	12.9	.98	11.4	.58
×	9.4	.62	36.0	1.00

Fig. 8. Correlation of Limiting Flows for Various Packings.

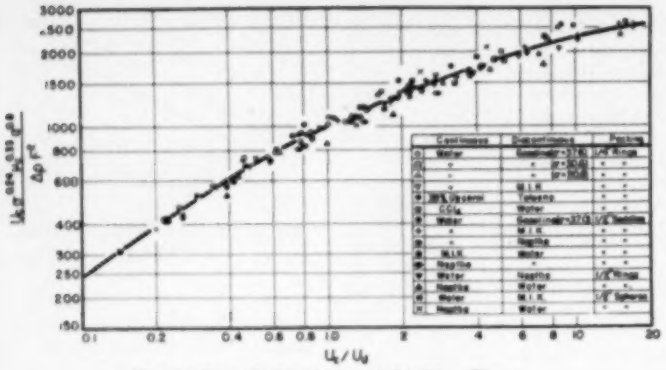


Fig. 9. General Correlation of Limiting Flows.

for a given packing the group $U_c\sigma^{0.33}\mu_c^{0.33}/\Delta\rho$ should be a unique function of the velocity ratio U_c/U_d. The lower curve of Figure 8 shows this function for all the data on ¼-in. rings. The proximity of all the points to a single line is in satisfactory agreement with the foregoing conclusions. Similar curves for the data of Blanding and Elgin on ½-in. Berl saddles and ½-in. clay spheres shown in Figure 8 indicate that the effects of the physical variables are approximately the same in these larger packings. Data for Berl saddles, particularly, include a wide variation in physical properties and confirm the proposed formulation of the variables. The range of physical properties included in these data is indicated in the legend of Figure 8.

Effect of Packing Characteristics

By trial and error it was found that the curves of Figure 8 could be superimposed by introduction of the group $a^{0.8}/F^2$ into the ordinate, where a is the external surface area of the packing per unit packed volume, square foot per cubic foot, and F is the void fraction of the packing. These variables are important in the generalization of gas-liquid flooding velocities (*4, 9-10*) and might be expected to be important in the present case. Unfortunately, the available data are too few and do not cover a sufficient range of packing properties to permit a more complete analysis. It is hoped that the effect of packing characteristics may be defined in a more fundamental manner when data become available on larger packings. With these reservations a final general correlation of all the data of Tables 3 and 4 is proposed as shown in Figure 9. In addition to the packings considered in Figure 8, the data of Blanding and Elgin for ½-in. Raschig rings and the data of this study for ½-in. Berl saddles are included in Figure 9. The satisfactory agreement obtained for the ½-in. Berl saddle data of the present study with the ½-in. packing data of Blanding and Elgin affords an encouraging tie between the two investigations. Thus it is believed that Figure 9 presents a satisfactory general correlation for use in extraction column design, although due caution should be exercised in extending the correlation to large diameter columns, large packings and packings of markedly different geometrical form from those considered here.

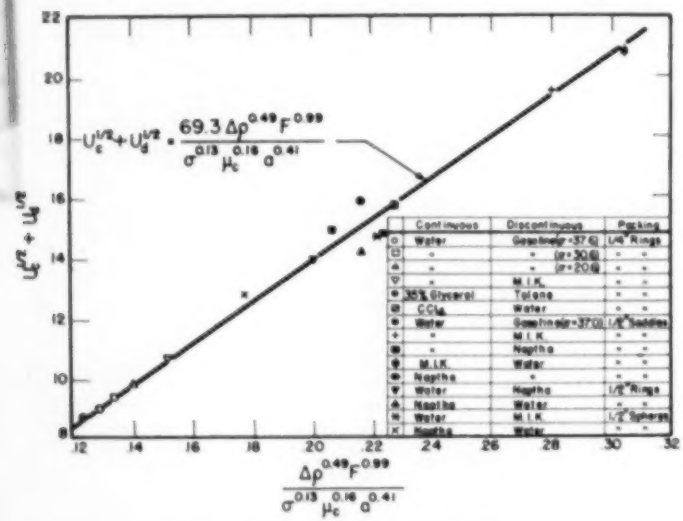


Fig. 10. Alternate Method of Correlation.

Alternate Methods of Correlation

The linear relation between the square roots of the flooding velocities as shown in Figure 3 suggested an alternate means of correlation leading to an algebraic expression for the limiting flows. The slope of the lines in Figure 3 are approximately unity, ranging from −0.93 to −1.17 for the data of the present study, suggesting that the sum $U_c^{1/2} + U_d^{1/2}$ is essentially constant. The relative constancy of this sum is indicated in Table 3 and also in Table 4 for the data of Blanding and Elgin. By assuming average values of the sum $U_c^{1/2} + U_d^{1/2}$ for each series of runs, and assuming that this summation could be expressed as exponential powers of the variables considered in the preceding section, the following equation was developed:

$$U_c^{1/2} + U_d^{1/2} = \frac{69.3\Delta\rho^{0.49}F^{0.99}}{\sigma^{0.13}\mu^{0.16}a^{0.41}} \quad (1)$$

The fit of the average values of $U_c^{1/2} + U_d^{1/2}$ by Equation (1) for the series of data of this study and of Blanding and Elgin is illustrated in Figure 10.

The similarity of the exponents in the right-hand side of Equation (1) to one-half the values of the exponents of the ordinate of Figure 9 suggested that the curve of this figure might be represented by a function of the form of Equation (1). Rearrangement of Equation (1) based on the exponents obtained for Figure 9 and an average empirical constant based on Figure 9 lead to the relation:

$$\frac{U_c\sigma^{0.24}\mu_c^{0.33}a^{0.8}}{\Delta\rho F^2} = \frac{3980}{\left[1 + \left(\frac{U_d}{U_c}\right)^{1/2}\right]^2} \quad (2)$$

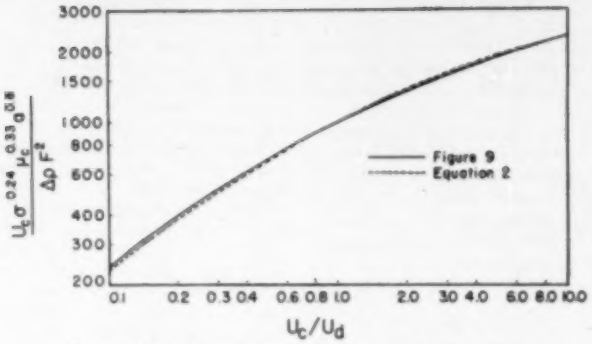


Fig. 11. Comparison of Eq. 2 with Graphical Correlation.

where:

U_c = superficial velocity of continuous phase, cu. ft./(sq. ft.) (hr.)

U_d = superficial velocity of discontinuous phase, cu.ft./(sq.ft.) (hr.)

σ = interfacial tension, dynes/cm.

μ_c = continuous phase viscosity, cp.

a = surface area of packing per unit volume, sq.ft./cu.ft.

$\Delta\rho$ = density difference between phases, lb./cu.ft.

F = void fraction of packing

readily available. Whether the graphical function is more accurate than Equation (2) is not certain in view of the difficulty in choosing the best line through the points of Figure 9. Either function is probably well within the limits of experimental error and uncertainty in the selection of the empirical constants.

Equation (2) suggests that the flooding conditions for a given column and packing may be expressed by a single equation containing one empirical constant, or "packing factor," characteristic of the packing under consideration. Denoting the packing factor by ϵ this equation may be written as follows:

$$\frac{U_c \sigma^{0.24} \mu_c^{0.33}}{\Delta\rho} = \frac{\epsilon}{\left[1 + \left(\frac{U_d}{U_c}\right)^{1/2}\right]^2} \qquad (3)$$

When reliable flooding data are available on an existing installation operating with one given pair of liquids, the constant ϵ in Equation (3) may be evaluated directly for prediction of performance of this column with new liquids or under new operating conditions. Thus, a minimum of one experimental point may be used to define the limiting flow characteristics of a packing. For preliminary estimation of the feasibility of some proposed new operation a lower limit may be placed on ϵ on the basis of the existing operating conditions, even though these conditions are below flooding. Use of Equation (3), with ϵ based on known operating conditions in the packing under consideration, should be preferable to use of Equation (2), particularly for prediction of flows in packings having uncertain or markedly different properties from those considered in the present study.

TABLE 5.—DATA (7)

Series *	U_c ft./hr.	U_d ft./hr.	U_c/U_d	U_c (Calculated) ft./hr.	% Deviation in U_c
17	86.5	13.1	6.61	86.0	—23.6
	41.6	30.6	1.36	36.2	—12.9
	14.8	47.2	0.31	16.6	+13.6
18	102.3	11.5	8.90	83.8	—18.0
	54.4	28.6	1.90	49.1	— 9.7
	20.4	47.0	.43	23.8	+16.6
	14.3	57.0	.25	16.9	+18.1

* Column diameter = 8.75 in.

Comment

Reproducibility of Correlation. Ordinarily in column design problems the ratio of the flow rates of the two phases is established from mass-transfer considerations. For any desired flow ratio the limiting continuous phase velocity may be estimated readily from Figures 9 or 11 or calculated by Equation (2). The accuracy of the correlation in reproducing the data is therefore reflected in the vertical separation of the points in Figure 9 from the best line through the data. For the 111 points shown,

The left-hand member of Equation (2) can be calculated from this equation as a function of the velocity ratio, and should correspond to the ordinate of Figure 9 if the functions are equivalent. As shown in Figure 11 this agreement is reasonably good. The calculated ordinates are about 3% below the estimated best line through the data at velocity ratios below 0.5 and are in good agreement at higher ratios.

Equations (1) and (2) may be considered equivalent within the accuracy to which the various exponents may be evaluated, and accordingly use of Equation (2) is recommended to be consistent with the graphical correlation in Figure 9. For convenience the solid curve of Figure 11 may be used when

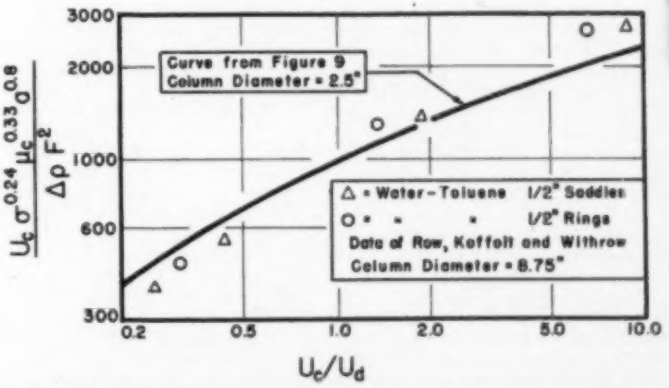


Fig. 12. Comparison of Correlation with Data on Larger Diameter Column.

representing data of Tables 3 and 4, the average deviation of the best line from the experimental points is 5.1% and the maximum deviation is 20%. This agreement is considered reasonably adequate for engineering design.

Wall Effect. Since data of this study and of Blanding and Elgin were obtained in columns of approximately 2.5 in. I.D. some preferential flow of the phases along the wall, or "wall effect," might be expected, particularly with ½-in. packings. In Figure 12 data of Row, Koffolt and Withrow (*7*) for ½-in. saddles and rings in a pyrex column of 8.75 in. diameter are compared with the curve of Figure 9. Agreement of these data with the general correlation is encouraging, and does not indicate a significant error due to wall effect. These data are given in Table 5, and packing characteristics and liquid properties are given in Tables 1 and 2 as series 17 and 18. The average deviation between calculated and observed values of U_c for the experimental velocity ratios is 16% for these data, and the net deviation taking both positive and negative deviations into account is 2.7%, the calculated values being 2.7% low. This agreement is believed satisfactory since these flooding data were taken incidental to a mass-transfer study, and not with the objective of determining the flooding points with high accuracy. However, in view of the few data considered in this comparison, caution is recommended in extending the present correlation to large diameter columns. A further detailed study of the effect of column diameter is needed.

Additional Variables. The present study is not so complete as would be desired, especially with respect to covering a sufficiently wide variation in the properties of the systems. It would be particularly desirable to investigate further viscosity effects with high continuous and discontinuous phase viscosities. Data on larger packings are needed to test or improve the applicability of the correlation over a greater variation in packing characteristics. Similarly a greater range of absolute densities and density differences should be studied. It is hoped that such studies will permit the development of a more fundamental equation for limiting flows. It is recognized also that a correlation in the form of dimensionless groups would be preferable to the present treatment. Numerous attempts to formulate such groups on the basis of the variables known to be significant were not successful. A more extensive knowledge of the variables which are influential, and the introduction of additional variables may facilitate a dimensionless correlation.

Conclusions

On the basis of the foregoing treatment it may be concluded that the present correlation is in satisfactory agreement with the available data on limiting flows in packed extraction columns. Unfortunately the range of available data is not sufficiently complete, and therefore the correlation must be used cautiously in the treatment of systems markedly different from those considered in its development.

Notation

a = sq.ft. of packing surface/cu.ft. packed volume

F = cu.ft. void space/cu.ft. packed volume; dimensionless

U = superficial velocity at flooding point; cu. ft./(sq. ft.)(hr.) = ft./hr.

ϵ = packing factor

μ = viscosity, centipoises

ρ = density, lb./cu.ft.

$\Delta\rho$ = density difference between phases, lb./cu.ft.

σ = interfacial tension, dynes/cm.

Subscripts:

c = continuous phase

d = discontinuous phase

Literature Cited

1. Appel, F. J., and Elgin, J. C., *Ind. Eng. Chem.*, **29**, 451 (1937).
2. Blanding, F. H., and Elgin, J. C., *Trans. Am. Inst. Chem. Engrs.*, **38**, 305 (1942).
3. Colburn, A. P., *Trans. Am. Inst. Chem. Engrs.*, **38**, 335 (1942).
4. Elgin, J. C., and Weiss, F. B., *Ind. Eng. Chem.*, **31**, 435 (1939).
5. Goss, W. H., *Trans. Am. Inst. Chem. Engrs.*, **38**, 337 (1942).
6. Harkins, W. O., *J. Am. Chem. Soc.*, **38**, 236 (1916).
7. Row, S. B., Koffolt, J. H., and Withrow, J. R., *Trans. Am. Inst. Chem. Engrs.*, **37**, 559 (1941).
8. Sherwood, T. K., Evans, J. E., and Longcor, J. V. A., *Trans. Am. Inst. Chem. Engrs.*, **35**, 597 (1939).
9. Sherwood, T. K., Shipley, G. H., and Holloway, F. A. L., *Ind. Eng. Chem.*, **30**, 765 (1938).
10. Zenz, F. A., *Chem. Eng. Progress*, **43**, 415 (1947).

Discussion

A. M. Ames (C. F. Braun & Co., Alhambra, Calif.): I want to issue one plea—for more information on larger columns. Professor Wilke indicated we need information on that line. We know little of such things as channeling in large-diameter columns, which we know happens. We know little also of the effects of channeling on H.E.T.P. and H.T.U. data as information on this is scanty in the literature. However, we have to start some place, and we have a lot of information here which is certainly worth while. I was impressed by the larger number of points shown in the correlation, and also by the close agreement that was found. Undoubtedly, there must have been a lot of trial-and-error work done in order to arrive at the constants used.

Were any of the well-known dimensionless groups applied to this correlation in an effort to find out whether they can be used to predict a particular correlation that we might be able to use? I noticed that Professor Wilke, and also F. H. Blanding and J. C. Elgin (*see* Literature Cited *2*), defined the flooding velocity as the point at which the discontinuous phase collects underneath the packing support at the base of the tower. I have heard of some research work that has been done on a small column, in which flooding was considered as the point where the continuous phase was carried overhead in the column. Have you any information on that or have you run into any such effect as that?

C. R. Wilke: We regret that we were unable to get the correlation developed into the form of dimensionless groups. We made numerous attempts at dimensionless analysis, and could not, among the variables we knew to be effective, develop dimensionless groups which were consistent with the observed results. It is possible that there are other terms, such as absolute densities of the phases, which if introduced could lead to suitable dimensionless expressions. However, in view of our lack of knowledge on the effects of these variables, we did not feel justified in introducing them into the correlation.

Regarding your second question on carry-over of the continuous phase at the flooding point, we did not observe this behavior in our experiments and were not aware of studies such as you mentioned. In our operations the interface between the continuous and discontinuous phases was held at a constant level in the upper end section of the column, and no difficulty was encountered in maintaining this condition.

(Presented at Tenth Regional Meeting, Los Angeles, Calif.)

MASS-TRANSFER RESISTANCES IN LIQUID-LIQUID EXTRACTION

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H.T.U. values for each liquid film were measured in a countercurrent, liquid-liquid extraction column for the two systems, isobutyraldehyde-water and 3-pentanol-water. The 2-in. I.D. column was operated in three ways: (1) as a spray column, (2) packed with ¼-in. Raschig rings, and (3) packed with ⅜-in. Raschig rings.

The H.T.U. of the discontinuous phase was found to be nearly independent of variations in the flow rate of either the continuous or discontinuous phase and of the three types of column operation.

The H.T.U. of the continuous phase was affected by both flow rates but could be correlated with the ratio of the flow rate of the continuous phase rate to that of the discontinuous phase by an equation of the form,

$$(H.T.U.)_C = \beta \left(\frac{L_C}{L_D} \right)^n$$

The value of β varied from 0.50 to 2.5 and n from 0.54 to 0.96 as the different fluids, isobutyraldehyde, water, and 3-pentanol, were made the continuous phase, presumably due to differences in physical properties. Variations in β could not be correlated with the Schmidt group, $\mu_C/\rho_C D$, possibly because of the lack of precision in the diffusivity values. However, changes in interfacial area with flow rates and physical properties may have been significant and, therefore, a contributing factor to the variation in n and the lack of correlation of β with the Schmidt group.

LIQUID-LIQUID extraction has achieved an important position as a commercial scale separation process, particularly in the manufacture of organic chemicals. In order to design extraction equipment, methods must be developed for correlating the rate of extraction with the operating variables and the properties of the chemicals involved. Before such correlations are possible there must be an accumulation of experimental data on rates of extraction for a number of chemical systems and for a wide range of operating conditions.

Considerable test data, summarized by Row, Koffolt and Withrow (*10*), have been reported for over-all rates of extraction. These data give the combined effect of the resistance to mass transfer in both liquid films of the extraction system. This information is of value in designing equipment for the same systems as investigated experimentally. However, it is extremely difficult to develop correlations from over-all resistance measurements which are generally applicable to systems and operating conditions for which no experimental data are available. On the other hand, the resistance of each individual film is not dependent upon as many variables and, therefore, should be easier to correlate. It is expected that each film resistance would be affected by the flow rates of both liquid streams, the construction details of the apparatus (tower diameter, size and type of packing, liquid distributors, etc.) and the properties of the film (viscosity, density, and diffusivity). Once the resistance of each film is known, the over-all resistance can be found by simple addition. If *H.T.U.* values are employed as a measure of the resistances, the relationship becomes

$$(H.T.U.)_{OC} = (H.T.U.)_C + (H.T.U.)_D \frac{m}{L_D/L_C} \quad (1)$$

where the subscripts C and D refer to the continuous liquid phase and the discontinuous liquid phase, respectively.

The experimental determination of individual film resistances is difficult in a normal liquid-liquid extraction system where three components are involved (two immiscible liquids and the diffusing solute). Brinsmade and Bliss (*3*) were able to separate the over-all resistance into contributions due to each film, but, as they point out, the method is satisfactory only when certain restrictions are placed upon the extraction system. Colburn and Welsh (*4*) avoided the problem of resolving measured over-all resistances by an ingenious method in which no solute is employed, but two partially miscible liquids are passed countercurrent to each other through the extraction column. If the mutual solubilities are small, the concentration of the diffusing component in one phase will be nearly 100% in the other phase. This means that the concentration of the diffusing component in the exit stream will be a measure of the resistance to diffusion in that phase and that the resistance to diffusion in the other phase will be essentially zero, because its concentration is nearly 100%. Thus, from the measurement of the concentration of the diffusing component in each exit stream, resistances and *H.T.U.* values can be evaluated for each film.

The purpose of this investigation was the determination of *H.T.U.* values for individual films for the two systems isobutyraldehyde-water and 3-pentanol-water by the method of Colburn and Welsh. Isobutyraldehyde and 3-pentanol have considerably different physical properties and were chosen in order that the *H.T.U.* data would reflect the

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* Present address: Pacific Vegetable Oil Corp., San Francisco, Calif.

Complete data on Tables 3 and 4 are on file (Document 2759) with the American Documentation Institute, 1719 N Street, N.W., Washington, D. C. Data can be obtained by remitting $0.50 for microfilm and $0.50 for photoprint.

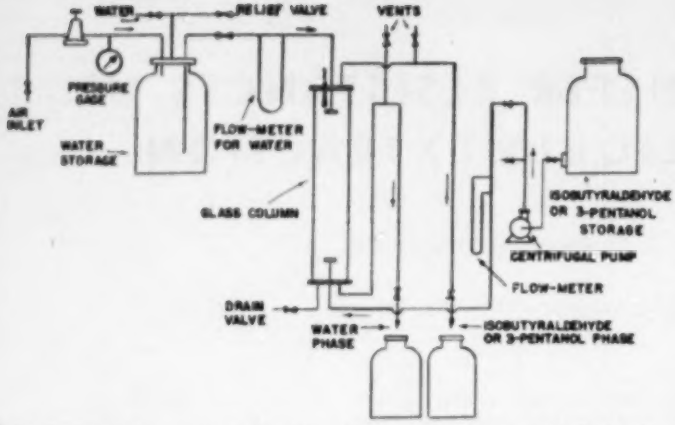

Fig. 1. Flow Diagram for Study of Mass-Transfer Resistances in Liquid-Liquid Extraction.

effect of variations in properties of the diffusing and solvent streams.

Method of Approach

The individual film *H.T.U.* values were computed from the measured concentrations of the diffusing component in each phase by using the defining Equation (5) for the number of transfer units; namely,

$$N = \int_{y_1}^{y_2} \frac{dy(1-y)_f}{(y_e - y)(1-y)} \quad (2)$$

In this investigation the concentration of diffusing component never attained values of more than a few per cent. Under such circumstances, both the actual concentration, y, in the main body of the liquid, and the concentration y_e corresponding to equilibrium between the two phases, will be small. Therefore, the mean value y_f of y and y_e will also be small, and $(1-y)_f$ will not differ significantly from $(1-y)$. Hence Equation (2) reduces to the following form:

$$N = \int_{y_1}^{y_2} \frac{dy}{(y_e - y)} \quad (3)$$

A further simplification can be made because the concentrations are small; that is, the logarithmic mean driving force can be used. This combined with the fact that the entering streams were pure components ($y_1 = 0$) leads to the equation,

$$N = ln \frac{y_e}{y_e - y_2} \quad (4)$$

where y_2 is the concentration of the diffusing component leaving the column. Finally, if the height of the column is Z,

$$H.T.U._{\cdot} = \frac{Z}{ln \frac{y_e}{y_e - y_2}} \quad (5)$$

By application of Equation (5) to both phases, the data obtained in any one test permit the evaluation of the *H.T.U.* for each liquid film. For example, if the two liquids fed to the tower are 3-pentanol and water, measurement of the concentration of water in the exit 3-pentanol stream and 3-pentanol in the water phase is sufficient to evaluate the *H.T.U.* for water diffusing through the 3-pentanol film and the *H.T.U.* for 3-pentanol diffusing through the water film.

Apparatus and Materials

A schematic flow diagram of the apparatus as a whole is shown in Figure 1. Liquid flow rates were measured with glass capillary flow meters before entering the extraction column. The water rate was maintained constant by applying a constant air pressure to the storage vessel as indicated in Figure 1. The isobutyraldehyde or 3-pentanol was pumped from a storage vessel at atmospheric pressure through the flow meter and into the column. The extraction column itself was made of sections of standard, 2-in. I.D. pyrex glass tubing with flanged ends so that its height could be varied. The top and bottom of the column were equipped with stainless steel headers which contained the inlet and outlet pipes for the liquid streams.

The lighter liquid, either isobutyraldehyde or 3-pentanol, was introduced at the bottom of the column and water at the top. A nozzle, consisting of a hemispherical cap containing 12 holes, 0.043 in. in diameter, was attached to the inlet pipe either at the top or bottom of the column in order to make one of the phases discontinuous.

It was necessary to determine a number of the physical properties of the isobutyraldehyde and 3-pentanol used in the test runs. These data as well as other characteristics of the liquids are as follows:

Isobutyraldehyde. Technical grade isobutyraldehyde from the Du Pont Co. was used as a base stock, and a fraction boiling between 63.5 and 64.5° C. separated for the extraction runs. The measured density and refractive index of this material at 20° C. were 0.7934 and 1.3730, respectively. Values reported in the literature (*6*) are 0.7938 and 1.3730 for pure isobutyraldehyde. Distillation of aqueous mixtures gave an azeotrope boiling at 59.3° C. and containing 4.82 g. of aldehyde/100 g. of water. The mutual solubilities of this fraction and water are reported in Table 1. The measured viscosity of the fraction was 0.632 cp. at 20° C. and 0.563 at 30° C.

3-Pentanol. Technical grade 3-pentanol from the Sharples Solvents Corp. was distilled, and a cut boiling between 113.5 and 115.5° C. used for the extrac-

TABLE 1.

Mutual Solubilities of Isobutyraldehyde, Water

Temperature, °C.	Solubility of isobutyraldehyde in water, wt. % isobutyraldehyde in aqueous solution.	Solubility of water in isobutyraldehyde, wt. % water in isobutyraldehyde solution.
20	7.80	2.76
25	7.14	2.91
30	6.83	2.96

Mutual Solubilities of 3-Pentanol, Water

Temperature, °C.	Solubility of 3-pentanol in water, wt. % 3-pentanol in aqueous solution.	Solubility of water in 3-pentanol, wt. % water in 3-pentanol solution.
20	5.68	9.65
25	5.15	9.85
30	4.74	10.10
35	4.50	10.34

tion tests. Mutual solubilities with water are shown in Table 1. Other measured properties are

Density (20° C.)	0.8202
Refractive index (30° C.)	1.4041
Viscosity at 20° C., cp.	4.72
Viscosity at 30° C., cp.	3.09

Viscosities reported by Leaf (*8*) for pure 3-pentanol are 4.84 at 20° C. and 3.09 at 30° C.

Water. Ordinary tap water was used without further treatment.

Scope of Investigation

Each of the two systems was studied with the column operated in three ways: (1) with no packing, i.e., as a spray column, (2) packed with ¼-in. Raschig rings, and (3) packed with ⅜-in. Raschig rings. For both systems, data were obtained with each liquid as the discontinuous phase. Ranges of flow rates investigated were approximately 650 to 2400 lb./(hr.)(sq.ft. of total cross-sectional area) for the continuous phase and 300 to 2400 lb./(hr.)(sq.ft.) for the discontinuous phase.

The effective height of the column during the investigation of the system isobutyraldehyde-water was 4.2 ft. The height was so chosen that the concentrations of the exit streams were not close to their saturation values, i.e., the solubilities reported in Table 1. This precaution increased the accuracy with which the driving force, $y_s - y$, could be evaluated. To prevent a close approach to saturation, the effective height had to be reduced to 2.2 ft. for the study of the 3-pentanol-water system.

Method of Analysis

Determination of Isobutyraldehyde in Aqueous Solutions. The reaction of isobutyraldehyde with hydroxylamine hydrochloride was utilized as a volumetric method (*1*) for analyzing the water phase leaving the column. Titration of the acidity of the reaction solution with standard alkali, using methyl orange as an indicator, gave a measure of the isobutyraldehyde content.

Determination of Water in Isobutyraldehyde Solutions. This analysis was abandoned after a study of several schemes. The hydroxylamine hydrochloride method, based upon determination of the aldehyde content, was inaccurate, because the small water content was dependent upon the difference between two large aldehyde quantities. Schemes dependent upon index of refraction or density measurements were of little value because the properties of the isobutyraldehyde solution varied rapidly with time, presumably due to oxidation and polymerization.

Fig. 2. Water Emerging from Dispersing Nozzle Into 3-Pentanol

The inability to determine small quantities of water in isobutyraldehyde prevented the evaluation of the *H.T.U.* for the isobutyraldehyde film for this system.

Determination of 3-Pentanol in Aqueous Solutions and Water in 3-Pentanol Solutions. The range of refractive index at 30° C. from pure water (1.3319) to 3-pentanol (1.4041) is sufficient to analyze accurately mixtures of the two components. This method was used to determine the 3-pentanol content of the aqueous phase leaving the extraction column and the water content of the 3-pentanol phase leaving the column.

TABLE 2.—FLOODING RATES FOR THE SYSTEM ISOBUTYRALDEHYDE-WATER

Continuous Phase—Water
Packing—⅜-in. Raschig Rings

Water Rate (lb.)/(hr.) (sq.ft.)	Isobutyraldehyde Rate (lb.)/(hr.) (sq.ft.)
2,600	1,340
2,380	1,480
2,110	1,700
1,800	1,950
1,000	2,680

Procedure and Performance

The procedure for making a run, was as follows:

When the heavier liquid (water) was made the continuous phase, it was introduced into the top of the column until the feed tube at the top of the column was immersed. At this stage, isobutyraldehyde was introduced through the nozzle at the bottom. This lighter liquid rose up in the form of globules and began to form a layer at the top. The interface between the lighter phase and the heavier phase at the top of the column was worked up or down as necessary by regulating the valve in the water stream leaving the column. The position of the interface was maintained at about 1 in. above the point of introduction of the heavier liquid into the column. When the lighter liquid was the continuous phase, the same valve was used to keep the interface at about 1 in. below the introduction of the lighter liquid at the bottom. Experience indicated that steady-state conditions were reached in a period which was equivalent to about four times the holdup of the column. For runs at medium flow rates the time required to reach equilibrium was about

TABLE 3.

System—Isobutyraldehyde-Water
Continuous Phase—Isobutyraldehyde
Packing—¼-in. Raschig Rings

1 Expt. No.	2 L_c	3 L_D	4 L_D/L_c	5 T_m	6 X_o	7 X_3	8 $(H.T.U.)_W$
18	645	1000	1.55	25.0	7.14	5.93	2.27
19	645	1636	2.54	25.0	7.14	5.76	2.56
20	645	2380	3.70	25.0	7.14	5.68	2.65
21	958	1000	1.045	24.0	7.37	5.94	2.47
22	958	1636	1.705	24.0	7.37	5.87	2.55
23	958	2380	2.49	24.0	7.37	5.78	2.65
24	1412	2380	1.69	24.0	7.37	5.99	2.42
25	1412	1636	1.16	24.0	7.37	6.06	2.34
26	1412	1000	0.708	24.0	7.37	6.10	2.30
30	2010	1636	0.815	23.5	7.32	6.13	2.37
29	2010	1000	9.497	23.5	7.32	6.30	2.14
68	956	685	0.718	22.5	7.47	6.36	2.20
69	956	1000	1.045	22.0	7.52	6.23	2.39
70	956	1636	1.715	22.0	7.52	6.15	2.47
71	956	2380	2.50	22.0	7.52	5.91	2.68
72	638	685	1.075	24.0	7.27	6.13	2.27
73	638	1000	1.57	23.0	7.38	6.05	2.45
74	638	1636	2.57	23.0	7.38	5.94	2.57
75	638	2380	3.74	23.0	7.38	5.78	2.75
76	638	685	1.075	26.0	7.06	5.98	2.36
77	638	1636	2.57	26.0	7.06	5.72	2.55
78	638	2380	3.74	26.0	7.06	5.65	2.64
79	1385	685	0.495	26.0	7.06	6.02	2.21
80	1385	1636	1.18	26.0	7.04	5.99	2.26
81	1385	2130	1.53	26.0	7.04	5.73	2.58
82	2010	685	0.341	27.0	7.00	6.03	2.09

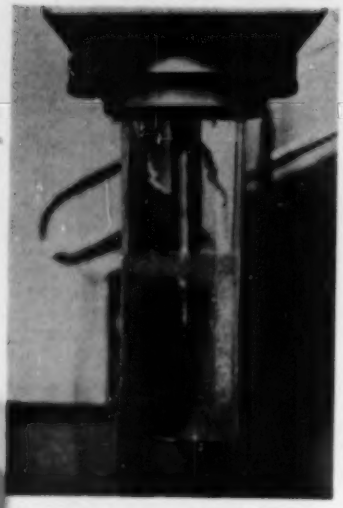

Fig. 3. 3-Pentanol Separating from Water Phase at Top of Column

thirty minutes. Top and bottom temperatures in the column were then noted and samples of both exit streams taken for analysis.

In the case of the packed column at low rates, the discontinuous phase appeared to emerge in the form of almost spherical globules. At higher rates it assumed the form of thin streams. Figure 2 shows a photograph of water emerging from the dispersing nozzle at low flow rates into the continuous phase of 3-pentanol. Figure 3 shows the separation of phases for the system 3-pentanol-water, the dispersed globules of 3-pentanol rising and separating into the 3-pentanol phase at the top of the column.

Investigations were normally carried out at rates much below the flooding values for the column. However, some flooding data were measured for ½-in. Raschig rings when water was the continuous phase and isobutyraldehyde the discontinuous phase. This information is shown in Table 2.

TABLE 4.

System—3-Pentanol-Water
Continuous Phase—Water
Packing—½ in. Raschig Rings

1 Expt. No.	2 L_C	3 L_D	4 L_D/L_C	5 T_m	6 X_1	7 X_2	8 Y_1	9 Y_2	10 $(H.T.U.)_C$	11 $(H.T.U.)_D$
176	2130	530	0.249	27.0	4.97	3.35	9.95	9.20	1.97	0.855
177	2130	350	0.165	27.0	4.97	2.65	9.95	9.40	2.91	0.764
178	2130	697	0.328	27.5	4.93	3.80	9.98	9.20	1.50	0.869
179	2130	798	0.375	30.0	4.74	4.06	10.10	9.40	1.13	0.827
180	1636	350	0.214	27.5	4.93	3.05	9.98	9.40	2.29	0.778
181	1636	530	0.324	30.3	4.73	3.65	10.11	9.40	1.49	0.833
182	1636	697	0.427	26.5	5.01	4.2	9.93	9.20	1.21	0.847
183	1636	798	0.488	30.3	4.73	4.2	10.11	9.40	1.01	0.833
184	2385	350	0.147	25.5	5.10	2.6	9.88	9.40	3.10	0.733
185	2385	530	0.222	26.0	5.06	3.05	9.90	9.20	2.40	0.833
186	2385	697	0.292	26.0	5.06	3.65	9.90	9.20	1.73	0.833
187	2385	798	0.335	26.0	5.06	4.0	9.90	9.40	1.41	0.739
188	2630	350	0.133	26.0	5.06	2.45	9.90	9.20	3.35	0.833
189	2630	530	0.201	29.8	4.76	3.15	10.08	9.40	2.04	0.822
190	2630	697	0.265	29.8	4.76	3.45	10.08	9.40	1.71	0.822

System—3-Pentanol-Water
Continuous Phase—3-Pentanol
Packing—½ in. Raschig Rings

215	697	438	0.49	28.5	4.85	4.45	10.02	5.45	0.887	2.81
216	697	438	0.63	28.2	4.87	4.45	10.01	6.10	0.902	2.35
217	697	522	0.75	28.0	4.89	4.45	10.0	6.35	0.917	2.16
218	697	610	0.878	28.0	4.89	4.45	10.0	6.80	0.917	1.93
219	530	283	0.535	29.0	4.815	4.45	10.05	5.90	0.803	2.49
220	1183	283	0.24	29.0	4.815	4.45	10.05	3.15	0.803	5.88
221	1183	438	0.371	28.5	4.85	4.45	10.02	4.40	0.812	3.82
222	1183	610	0.517	28.5	4.85	4.45	10.02	5.20	0.812	3.02
223	1610	283	0.176	29.0	4.815	4.45	10.05	2.40	0.803	8.06
224	530	610	1.15	29.0	4.815	4.45	10.05	7.50	0.803	1.61
247	697	1628	2.35	25.8	5.08	4.51	9.89	9.20	1.01	0.83
248	697	1965	2.84	25.5	5.11	4.51	9.88	9.70	1.03	0.55
249	697	1266	1.81	25.5	5.11	4.51	9.88	9.60	1.03	1.07
250	1183	1628	1.38	25.5	5.11	4.45	9.88	8.20	1.07	1.24
251	815	1628	2.01	25.5	5.11	4.45	9.88	8.70	1.07	1.03

Results

The observed exit stream concentrations and *H.T.U.* values computed according to Equation (5) are shown for a few of the runs in Tables 3 and 4. Complete experimental data are on file with the American Documentation Institute. For most of the runs the column height was sufficient to give from one to two transfer units.

H.T.U. of Discontinuous Phase. When the *H.T.U.* values for the discontinuous phase were plotted versus the ratio of the flow rates for the discontinuous and continuous phases, L_D/L_C, straight lines were obtained. Such plots are shown in Figures 4, 5, and 6 for both systems. There is no figure for isobutyraldehyde as the discontinuous phase because of the inability to determine accurately the water content of this phase.

The outstanding feature of these charts is the small variation of the *H.T.U.* with the ratio of the flow rates. An examination of the data in Tables 3 and 4 indicates that the variation with each individual flow rate (at constant values of the other flow rate) is also small. Colburn and Welsh (*4*) in their study of the systems isobutanol-water also obtained nearly constant values for the *H.T.U.* of the discontinuous phase. It would appear that the flow rates of the two phases have little effect on turbulence conditions, and hence, on the rate of diffusion within the globules of the discontinuous phase.

It is interesting to note that, despite the difference in viscosities and calculated diffusivities between water and 3-pentanol (Table 7), the *H.T.U.* values shown in Figures 5 and 6 are about the same no matter which liquid is the discontinuous phase. If the diffusivities are correct, this is not in agreement with the concept that the controlling factor in determining the rate of diffusion within the globules of the discontinuous phase is molecular diffusion, for then the *H.T.U.* should be inversely proportional to the diffusivity. Furthermore, the *H.T.U.* for isobutyraldehyde diffusing into water (Fig. 4) is about three times as large as those for the 3-pentanol-water system, and yet, the calculated diffusivity of isobutyraldehyde into water is larger than

TABLE 5.—EQUATIONS FOR (H.T.U.) OF CONTINUOUS PHASE

Continuous Phase	Discontinuous Phase	Column Operation	Equation
Water	Isobutyraldehyde	Spray	$(H.T.U.)_C = 2.47 \left(\frac{L_C}{L_D}\right)^{0.34}$
		½ in. Raschig Rings	$= 2.28 \left(\frac{L_C}{L_D}\right)^{0.39}$
		¼ in. Raschig Rings	$= 1.93 \left(\frac{L_C}{L_D}\right)^{0.23}$
Water	3-Pentanol	Spray	$(H.T.U.)_C = 0.66 \left(\frac{L_C}{L_D}\right)^{0.66}$
		½ in. Raschig Rings	$= 0.51 \left(\frac{L_C}{L_D}\right)^{0.54}$
		¼ in. Raschig Rings	$= 0.50 \left(\frac{L_C}{L_D}\right)^{0.56}$
3-Pentanol	Water	Spray	$(H.T.U.)_C = 2.10 \left(\frac{L_C}{L_D}\right)^{0.10}$
		½ in. Raschig Rings	$= 1.90 \left(\frac{L_C}{L_D}\right)^{0.57}$
		¼ in. Raschig Rings	$= 1.66 \left(\frac{L_C}{L_D}\right)^{0.57}$

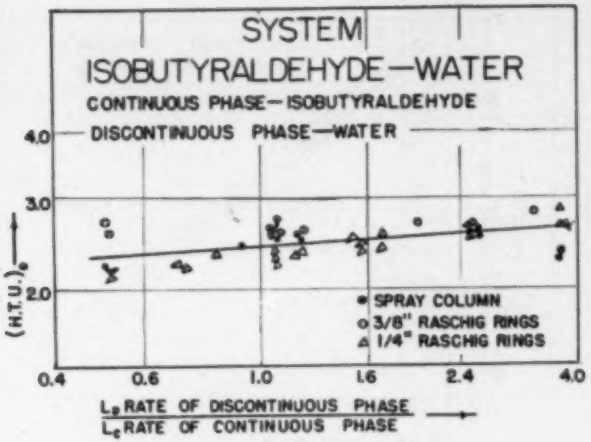

Fig. 4.

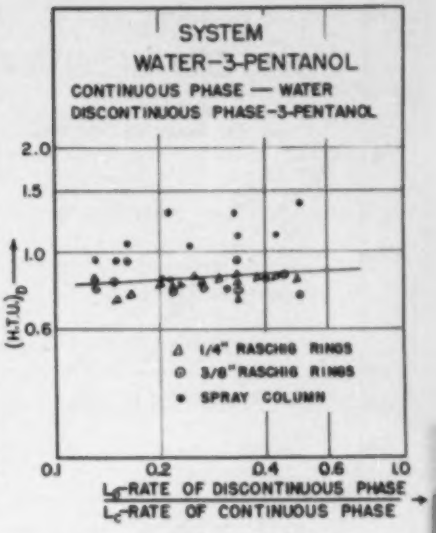

Fig. 5.

that of 3-pentanol into water (Table 7). It may be that the explanation for this behavior lies in the values of the calculated diffusivities. In the absence of experimental data these were computed from Arnold's equation (*2*) and Wilke's correlation (*12*) as described in the next section. . .

H.T.U. of Continuous Phase. Flow rates of both the continuous and discontinuous phases affected the *H.T.U.* of the continuous phase. However, the results could be correlated by plotting the *H.T.U.* versus the ratio of the flow rates as shown in Figures 7, 8, and 9. The straight lines were located from the data according to the method of least squares, with no attempt made to obtain parallel lines for different types of operation. While the *H.T.U.* values for the column packed with ¼-in. Raschig rings are the lowest, as would be expected, the decrease due to the use of packing is not large. Values for spray operation are about 25% larger than those for the ¼-in. packing for both systems. In the study of the isobutyraldehyde-water system with water as the continuous phase (Fig. 7) some data were obtained with a different size nozzle (no. 1) than that (no. 2) used for all the other tests. Nozzle number 1 contained 12 holes, 0.03 in. in diameter. Experimental runs were made with nozzle number 1 only for the ¼-in. rings. Results in Figure 7 indicate that varying the size of the holes in the nozzle from 0.03 to 0.043 in. had no appreciable effect upon the (*H.T.U.*) values. However, this size range is not large, and

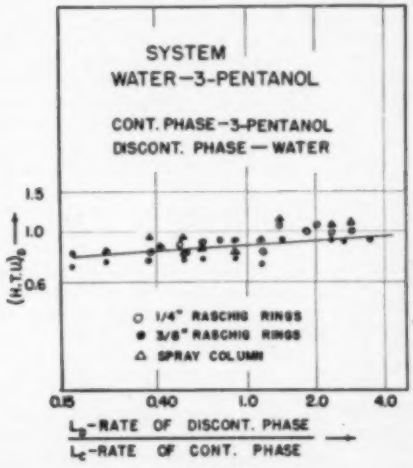

Fig. 6.

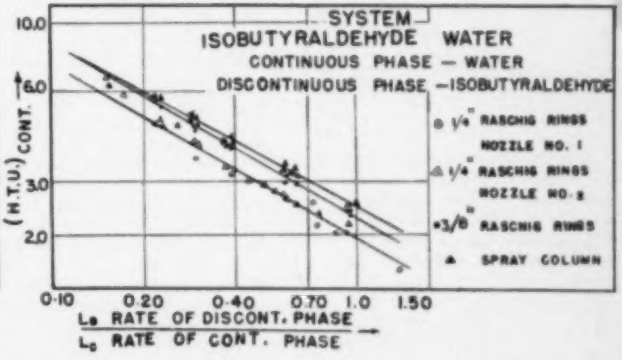

Fig. 7.

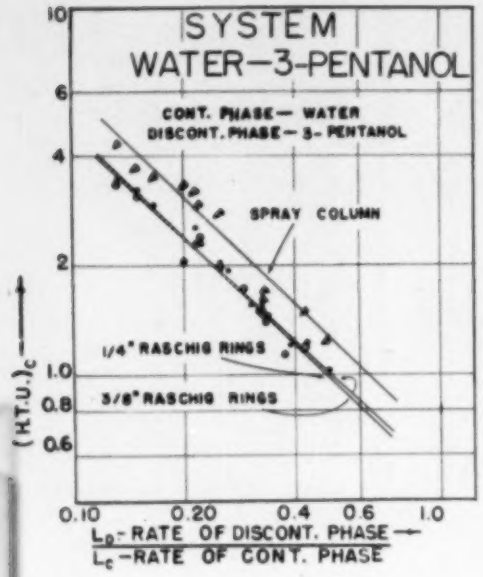

Fig. 8.

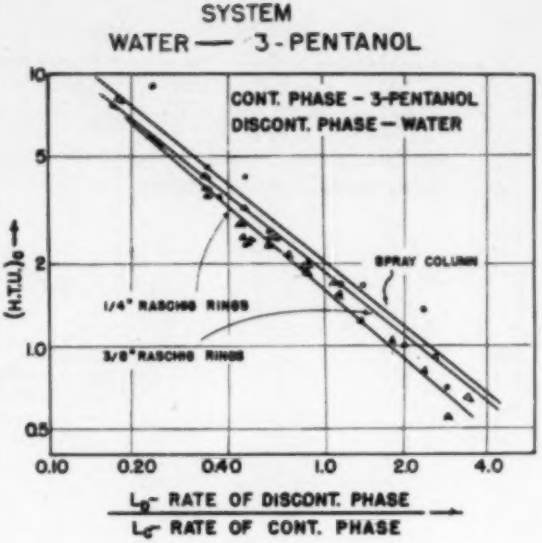

Fig. 9.

wider variation might produce significant effects.

Empirical equations corresponding to the straight lines shown in Figures 7, 8, and 9 are given in Table 5.

Hunter and Nash (*7*) predicted that the mass-transfer coefficient for the continuous phase would be a function of the Reynolds number and Schmidt number for that phase. Brinsmade and Bliss (*3*) took into consideration the possibility of the Reynolds number of the discontinuous phase affecting the result; their equation in terms of the height of a transfer unit is

$$(H.T.U.)_c = a(Re_c)^n(Re_D)^q\left(\frac{\mu_c}{\rho_c D}\right)^p \qquad (6)$$

Since the Reynolds number is equal to dL/μ, Equation (6) can be written

$$(H.T.U.)_c = a\left(\frac{dL_c}{\mu_c}\right)^n\left(\frac{dL_D}{\mu_D}\right)^q\left(\frac{\mu_c}{\rho_c D}\right)^p \qquad (7)$$

By noting that the length factor d in the Reynolds number is the same for both phases and then comparing Equation (*7*) with the correlations in Table 5, it is apparent that $q = -n$. With this simplification Equation (*7*) may be written,

$$(H.T.U.)_c = a\left(\frac{L_c}{\mu_c}\times\frac{\mu_D}{L_D}\right)^n\left(\frac{\mu_c}{\rho_c D}\right)^p \qquad (8)$$

and similarly, Equation (6) becomes,

$$(H.T.U.)_c = a\left(\frac{Re_c}{Re_D}\right)^n\left(\frac{\mu_c}{\rho_c D}\right)^p \qquad (9)$$

If the empirical expressions (8) and (9), based upon dimensional analysis, are satisfactory for correlating the *H.T.U.* of the continuous phase, the exponent n should be independent of the physical properties of the system; i.e., n should not vary from system to system. While the information in Table 5 indicates that n varies only from 0.83 to 0.98 depending upon which liquid is the continuous phase, within the pentanol-water system, it also indicates that there is a considerable variation, 0.54 to 0.98, in comparing the isobutyraldehyde-water and 3-pentanol-water systems. The only other data available are those of Colburn or Welsh (*4*) for the system isobutanol-water. Their equations, similar to those in Table 5, showed n equal to 0.75 irrespective of which liquid was the continuous phase. It may be that the differences in n are caused by variations in the effective interfacial area from one system to another. Any changes in interfacial area would affect the *H.T.U.* since the two quantities are inversely proportional to each other.

That the *H.T.U.* of the continuous phase is dependent upon the properties of the system is readily seen from the following data taken from Figures 7, 8, and 9 at

$$L_c/L_D = 1.0$$

TABLE 6.

System	Continuous Phase	$(H.T.U.)_c$ (¾ in. rings)
Isobutyraldehyde-water	Water	2.3 ft.
3-Pentanol-water	Water	0.5 ft.
3-Pentanol-water	3-Pentanol	1.9 ft.

In attempting to reconcile these differences in *H.T.U.* values by variation in the Schmidt group according to Equation (9), the problem of evaluating the diffusivities presents a serious difficulty. Experimental data for the diffusivity of some alcohols into water are available and have been used by Arnold (*2*) to evaluate the so-called abnormality factors in his equation for calculating diffusivities. Arnold's equation should give good results for evaluating the diffusivity of 3-pentanol and isobutanol into water and was used for this purpose. It is

$$D = \frac{0.01\left(\frac{1}{M_a}+\frac{1}{M_b}\right)^{1/2}}{A_a A_b (V_a^{1/3}+V_b^{1/3})^2(\mu_a)^{1/2}} \qquad (10)$$

where the subscripts a and b refer to the diffusing component and the solvent, respectively. A represents the abnormality factor.

In the absence of any experimental information for the diffusivity of aldehydes into water, D for isobutyraldehyde into water was evaluated by the method suggested by Wilke (*12*) which is based upon the molal volume of the solute and the Stokes-Einstein equation.

Such severe assumptions should not be required for obtaining the diffusivities of water into the alcohols, since Randall, Longtin, and Weber (9) measured the diffusivity of *n*-butanol into water at 30° C. Thus the corresponding values for isobutanol and 3-pentanol into water should be obtainable with reasonable accuracy by applying the Stokes-Einstein equation in the following way:

$$\left(\frac{D\mu}{T}\right)_{n\text{-butanol}} = \left(\frac{D\mu}{T}\right)_{3\text{-pentanol}} = \left(\frac{D\mu}{T}\right)_{\text{isobutanol}} \qquad (11)$$

However, this approach led to diffusivities which were unreasonably large, about 50×10^{-5} cm./sec. Hence, it was necessary again to use the correlation of Wilke for estimating D values for the alcohols diffusing into water.

Diffusivities so computed for all the systems along with the viscosities and Schmidt group ($\mu_C/\rho_C D$) values are given in Table 7. If Equation (9) is valid, a plot of $(H.T.U.)_C(R\epsilon_D)^n (R\epsilon_C)^{-n}$ versus ($\mu_C/\rho_C D$) should give a straight line on logarithmic paper. Also the slope of the line must be positive since the exponent p must be positive to permit a decrease in $(H.T.U.)_C$ with an increase in D. Reference to the data in Table 7 shows this will not be the case. For example, for the 3-pentanol-water system (System *B*, pentanol diffusing into water) ($\mu_C/\rho_C D$) is about 1000, while for isobutyraldehyde diffusing into water (System *A*) the value is 760-850, depending upon the temperature. This decrease in Schmidt number should be accompanied by a decrease in $(H.T.U.)_C$, but instead the data in Table 7 shows that $(H.T.U.)_C(R\epsilon_D)^n (R\epsilon_C)^{-n}$ increases from about 0.20 to 3. Information in Table 6 indicates the same lack of correlation: namely, that $(H.T.U.)_C$ at a given ratio of flow rates is larger for isobutyraldehyde diffusing into water than for 3-pentanol diffusing into water, although ($\mu_C/\rho_C D$) is smaller for the aldehyde system.

While it is possible that the failure of Equation (9) is due to inaccurate diffusivities, a more important factor may be the variations in interfacial area between the several chemical systems. The evidence for this is that a more satisfactory interpretation of the data, than Equation (9) permits, can be obtained by omitting the effect of the diffusivities. Thus the interfacial area would not be expected to depend upon the diffusivity but would be influenced by the viscosity. This idea was tested by plotting

$$H.T.U.\left(\frac{L_D}{L_C}\right)^n$$

which is equal to β the coefficient in the equations shown in Table 5, versus the viscosity ratio μ_C/μ_D. While the results (Fig. 10) do not show an adequate correlation, this approach is more satisfactory than Equation (9), based upon inclusion of the Schmidt group. A better analysis of the importance of the interfacial area in affecting *H.T.U.*

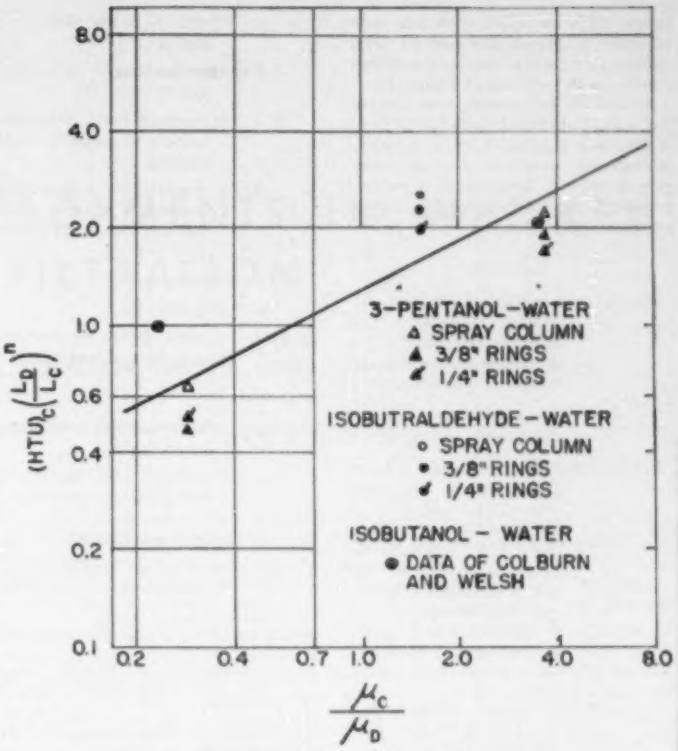

Fig. 10. Effect of Physical Properties on (HTU).

TABLE 7.—VARIATION OF $(H.T.U.)_C$ WITH PHYSICAL PROPERTIES

Nature of Column	Mean Temperature of Runs —° C.	μ_C cp.	$D \times 10^5$ sq.cm./sec.	n	$(H.T.U.)(R\epsilon_D)^n (R\epsilon_C)^{-n}$	$\frac{\mu_C}{\rho_C D}$	$\frac{\mu_C}{\mu_D}$
A. System: Isobutyraldehyde-Water with Water as the Continuous Phase							
Spray Column	26.2	0.870	1.15	0.54	3.2	760	1.69
⅜-in. Raschig Rings..	26.1	0.871	1.15	0.58	3.1	760	1.69
¼-in. Raschig Rings..	23.7	0.921	1.09	0.58	2.8	850	1.65
B. System: 3-Pentanol-Water with Water as the Continuous Phase							
Spray Column	26.5	0.864	0.87	0.96	0.20	1000	0.29
⅜-in. Raschig Rings..	28.2	0.832	0.89	0.94	0.16	940	0.31
¼-in. Raschig Rings..	27.5	0.845	0.88	0.96	0.16	960	0.30
C. System: 3-Pentanol-Water with 3-Pentanol as the Continuous Phase							
Spray Column	28.9	3.10	1.15	0.83	6.3	3220	2.78
⅜-in. Raschig Rings..	30.3	2.96	1.20	0.87	6.0	3040	2.72
¼-in. Raschig Rings..	27.6	3.27	1.06	0.87	5.4	3730	2.97
D. System: Isobutanol-Water with Water as the Continuous Phase (4)							
Packed Column	24.5	0.904	0.94	0.75	0.27	960	0.266
E. System: Isobutanol-Water with Isobutanol as the Continuous Phase							
Packed Column	25.2	2.30	1.05	0.75	5.4	3930	2.71

values might be obtained if data were available to permit inclusion of other pertinent properties, such as the surface tension, in the abscissa of Figure 10.

Results of this investigation indicate that a more accurate knowledge of liquid diffusivities and, especially, a means of determining interfacial areas are necessary in order to determine how physical properties affect mass-transfer rates in extraction processes.

Notation

A_a, A_b = abnormality factors of diffusing component and solvent, respectively, for use in Arnold's diffusivity equation, dimensionless

D = diffusivity of the diffusing component, sq.cm./sec.

$H.T.U.$ = height of a transfer unit, ft. Subscript w designates water phase and p the 3-pentanol phase. Thus, $(H.T.U.)_w$ refers to the height of a transfer unit for a substance diffusing into the water phase. Subscripts C and D designate continuous and discontinuous phases, respectively.

L = liquid mass velocity, lb./(hr.)(sq.ft. of superficial cross-sectional area)

M = molecular weight

m = slope of equilibrium curve, i.e., a curve of the concentration of a solute in one liquid vs. its corresponding equilibrium concentration in a second liquid not miscible with the first

n, q = exponents on Reynolds number, dimensionless

Re = Reynolds number, dL/μ, dimensionless; d is the length dimension

T_m = mean temperature in column, ° C.

V = molecular volume at normal boiling point, cc./g. mole

Y or X = concentration of diffusing component in solvent, wt. %. Y is used for wt. % water in isobutyraldehyde or 3-pentanol. X is wt. % isobutyraldehyde or 3-pentanol in water

y = concentration of diffusing component in solvent, weight fraction = $Y/100$. y_s is the solubility of diffusing component in solvent. y_l is the mean of y and y_s

Z = effective height of extraction column, ft.

α = a constant for a particular extraction column and packing

β = a constant for a particular extraction column, packing and liquid-liquid system

ρ = density, g./cc.

μ = viscosity, cp.

$\mu_c/\rho_c D$ = Schmidt group for continuous phase, dimensionless

SUBSCRIPTS:

1, 2 = inlet and outlet conditions, respectively

c, d = continuous and discontinuous phases, respectively

Literature Cited

1. Allen's "Commercial Organic Analysis," P. Blakiston's Son and Company, Philadelphia, Pa. Vol. 1, p. 23, 5th Edition (1923).
2. Arnold, J. H., *J. Am. Chem. Soc.*, **52**, 3937 (1930).
3. Brinsmade, D. S., and Bliss, H., *Trans. Am. Inst. Chem. Engrs.*, **39**, 679 (1943).
4. Colburn, A. P., and Welsh, D. G., *Trans. Am. Inst. Chem. Engrs.*, **38**, 179 (1942).
5. Colburn, A. P., *Trans. Am. Inst. Chem. Engrs.*, **35**, 211 (1939).
6. Hodgman, C. D., "Handbook of Chemistry and Physics," Chemical Rubber Publishing Co., Cleveland. 29th Edition, p. 843 (1948).
7. Hunter, T. G., and Nash, A. W., *J. Soc. Chem. Ind.*, **51**, 285 T (1932).
8. Leaf, C. W., Sharples Chemicals Corp., Personal Communication.
9. Randall, M., Longtin, B., and Weber, H. J., *J. Phys. Chem.*, **45**, 343 (1941).
10. Row, S. B., Koffolt, J. H., and Withrow, J. R., *Trans. Am. Inst. Chem. Engrs.*, **37**, 559 (1944).
11. Sherwood, T. K., "Absorption and Extraction," McGraw-Hill Book Co., New York, p. 167 (1937).
12. Wilke, C. R., *Chem. Eng. Progress*, **45**, 218 (1949).

Discussion

Theodore Baba (Kellex Corp., New York, N. Y.): I get the impression that the *H.T.U.* values which you found were the same for spray towers as for packed towers. Is that so and can you offer an explanation for it?

J. M. Smith: We found that the *H.T.U.* values did not vary with the type of operation of the tower for the discontinuous phase. However, for the continuous phase, there was an increase in the *H.T.U.* values of roughly 25% for the spray column in comparison with ½-in. ring packing.

Theodore Baba: Was any attempt made to determine flooding velocities and to compare them with Wilke's correlation which was presented at the recent California meeting?

J. M. Smith: A few flooding velocity measurements were made, but insufficient data were obtained to attempt a correlation with physical properties.

Leo Garvin (Oklahoma A & M College, Stillwater, Okla.): Did you find any difference in the results of the calculations for the diffusivity by the method of Arnold and the method of Wilke.

J. M. Smith: The Arnold method involves two abnormality factors which generally must be estimated. Hence, it is difficult to make an exact comparison of the two equations. For systems where the abnormality factors were known the two equations agree.

Anonymous: Alluding to Dr. Spaght's "mental block" I wonder if perhaps we have a "mental block" in mass-transfer processes here, that is, basing our entire analysis on the concepts of diffusivity or diffusion through a hypothetical film; perhaps we need to take an entirely new look at the process. If diffusivity is an important contributing factor, then the efficiency in transferring a multicomponent mixture should be a great deal less than in a binary mixture, that is, because the molecules interfere with one another in a diffusional process but experimentally that doesn't seem to be the case. You get just about as good an efficiency with ten components as you get with two.

J. M. Smith: Considerable progress might be made by leaving the classical approach and starting out with a new viewpoint.

Rex E. Leuze (Oak Ridge National Laboratory, Oak Ridge, Tenn.): Do you have any information on the change of *H.T.U.* with total throughput at a constant ratio of the continuous and discontinuous phases.

J. M. Smith: We obtained data at constant values of one flow rate for varying values of the other flow. As the flow rate of the dimensionless phase increased, the *H.T.U.* of the continuous phase decreased; as the rate of the continuous phase increased, the *H.T.U.* value increased.

G. T. Skaperdas (The M. W. Kellogg Co., New York, N. Y.): Can you tell roughly where your flow rates were with respect to flooding the tower? Were they down about one-tenth of the flooding capacity or up to 80 per cent of it?

J. M. Smith: The column was operated from 30% to 70% of flooding flow rates.

(*Presented at Eleventh Regional Meeting, Tulsa, Okla.*)

RECENT DEVELOPMENTS IN WHISKEY FILTRATION

DONALD M. HARMER, PAUL J. KOLACHOV, LeROY A. SMITH, and H. FREDERICK WILLKIE

Joseph E. Seagram and Sons, Inc., Louisville, Kentucky

Many new, improved filters are available now to the beverage industry. Previous work in selecting the best filter for the job was limited to such factors as costs, flow rate, throughput, floor space, and ease of operation. Relative clarity of the filtrates was determined by arbitrary methods of inspection.

Recent development work has taken a different approach to the problem. Laboratory studies preselect the most desirable filter media; plant trials confirm the results and establish optimum operating conditions. Clarity results are interpreted in the laboratory by use of a photonephelometer.

Filtration of whiskey is accomplished in two steps, namely, the removal of barrel char or primary filtration and the "polishing" or secondary filtration of the finished blend.

A horizontal-plate filter replaces a vertical-screen filter and a pulp filter in series. Cost of primary filtration is reduced 70%. Removal of barrel char is consistently better. Flow rates increase 20%; total gallons filtered, between cleaning cycles, is three times greater.

The superiority of the sealed-disc filter for polishing filtration of whiskey is clearly demonstrated. Over-all operating costs are lower than the stone or the spool filter. Product clarity is improved.

LITERATURE references to the subject of clarification of whiskey and other beverage products are scarce and a systematic study has been reported in only a few instances. In 1942, Schmitt, Kolachov and Willkie (*4*) published data comparing various equipment then used for whiskey filtration; conclusions were made primarily on the basis of operating cost.

The following studies establish operating data on improved filters recently introduced for industrial use. An attempt is made to evaluate filtrate clarity through the use of a photonephelometer. This replaces the traditional visual method of inspection for experimental work by establishing a relative index for clarity which can be duplicated.

Blending Process

The process used for blending whiskeys is illustrated by the flow diagram (Fig. 1). After tax payment, barrels of matured straight whiskeys and spirits are emptied into conventional dump troughs, a 25-mesh, stainless steel screen removes the larger particles of char which come off the barrel. The remaining char is removed by the primary filter and the whiskey is pumped to glass-lined processing tanks.

At this point, the other components are added and agitated to produce the finished blend. The blending of the various whiskeys often causes a slight precipitation or haze in the product. Baker and Barkenbus (*1*) describe a "haze cloud" of insoluble fatlike material that appears in the whiskey distillate when the alcohol concentration is reduced. This haze cloud common to most straight whiskeys, might be partially eliminated by conducting the primary filtration at low temperatures (30°-50° F.). However, the cost of this procedure is excessive and, for effective removal of residual haze, the finished whiskey blend is pumped through sec-

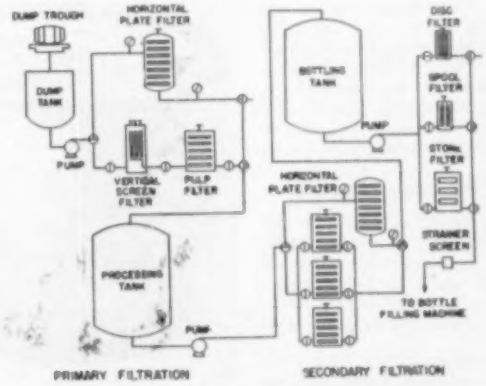

Fig. 1. Blending Process, From Barrel to Bottle.

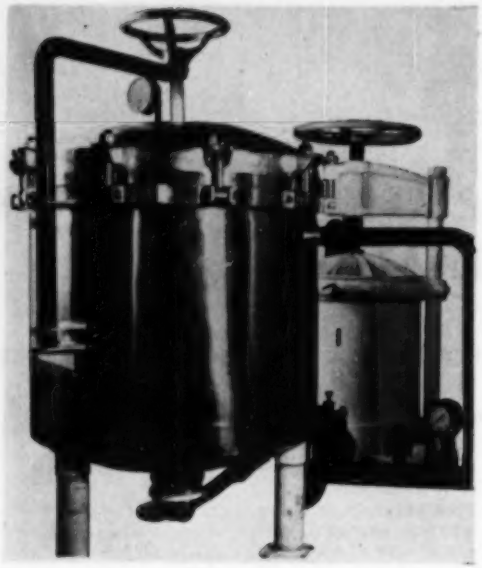

Fig. 2. Sparkler Filter, Exterior View.

ondary filters and then to glass-lined bottling tanks. Here a rectifying tax is paid and the whiskey is ready for bottling.

Final filtration of the product occurs on the bottling line immediately before the bottle-filling equipment. A filter in this location serves as a safety factor in preventing contamination of the finished package. When the whiskey blend is permitted to stand, even for a period of several hours, dissolved solids tend to settle out in storage tank and pipe lines; the scale, thus formed, is not readily soluble and must be removed.

Purpose of Study

Previous filtration equipment required extensive maintenance or replacement and operating costs were excessive. Newly developed filters showed considerable promise of simplifying the operation. Furthermore, occasional clarity rejections on the bottling lines stressed the need for a system to assure a "bright, lint-free" product.

Primary Filtration Equipment

The larger pieces of wood char are normally removed from the barrel whiskey by a 28-gage, 00 perforated stainless steel screen (625 holes/sq.in., .020 in. diameter). Whiskey flows by gravity to a constant-level dump tank.

Vertical Screen and Pulp Filters. To remove any remaining barrel char the whiskey is pumped from the dump tank through a vertical-screen type filter and then through a pulp-pad filter. The first filter consists of five envelope-shaped Monel screens (30¼ in. by 23¼ in., 28-gage wire cloth, 250 holes/sq.in.). The second filter contains twelve horizontal pads (23 in. diameter, 2 in. thick) made of digested alpha-cellulose pulp. A total filtering area of approximately 120 sq.ft. is available.

Horizontal Plate Filter. The experimental unit (Fig. 2) was installed in parallel with existing equipment. This horizontal-plate filter, constructed of type 304 stainless steel, is made by the Sparkler Manufacturing Co. Twelve 33-in. diameter plates, 2 in. deep are assembled as a cartridge outside the filter body (Fig. 3). Each plate contains a perforated screen which supports the filter paper. A rayon-reinforced paper is used with a conventional high alpha-cellulose sheet. Whiskey enters the plate through ports on the periphery, solids collect on the filter media and the clear filtrate is discharged through a center column (Fig. 4). This unit provides 65 sq.ft. of filtering area (*3*).

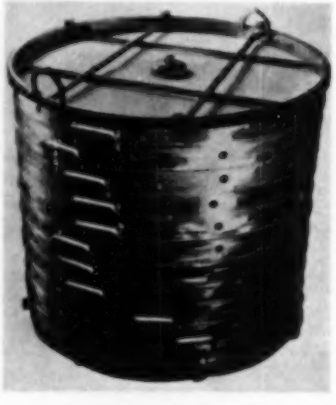

Fig. 3. Plate Assembly, Sparkler Filter

Secondary Filtration Equipment

Pulp Filters. To meet normal production requirements, a flow rate of 100-120 gal./min. is required between the blending and bottling tanks. Two or three pulp filters in parallel are needed (150 sq.ft.) to meet these conditions.

Horizontal-plate Filter. The horizontal-plate filter, described previously, was installed in parallel with the pulp filters. A 150-gal. tank and pump were provided to prepare the precoat slurry for this filter. A high alpha-cellulose, iron-free pulp, *SW 40b* Solka-Floc made by the Brown Co., was selected as the filter aid. Differential quality tests showed that this pulp had no effect on the taste or color of the whiskey.

Bottling Line Filtration Equipment

Polishing filters for use on the bottling line had become standardized with two types, the cotton-spool filter and the permeable-stone filter. Both filters meet an initial requirement for minimum floor space. The spool filter consists of 12 cotton-yarn tubes (2½ in. diameter, 8 in. height). These spools are wound in a definite pattern around a tinned-copper screen core, providing a media of uniform density throughout (Fig. 5). The stone filters consist of six stones (No. 20 permeability) attached to a central discharge pipe. Each stone is 1 in. thick, 7½ in. in diameter.

Sealed-disc Filter. A sealed-disc filter supplied by Alsop Engineering Corp. was installed in parallel with the cotton-spool filter on the bottling line at the Seagram plant at Lawrenceburg, Ind. The entire unit is constructed of type 316 stainless steel. The filter consists of 24 narrow sludge rings and 24 envelope-shaped perforated screens assembled on a center discharge screen column as shown in Figure 6. A Republic Seitz Filter Corp. filter disc is inserted between each pair of filter screens and the entire unit is clamped together to provide a positive seal.

A new filtration principle is employed in the sealed-disc filter (*3*). Whiskey en-

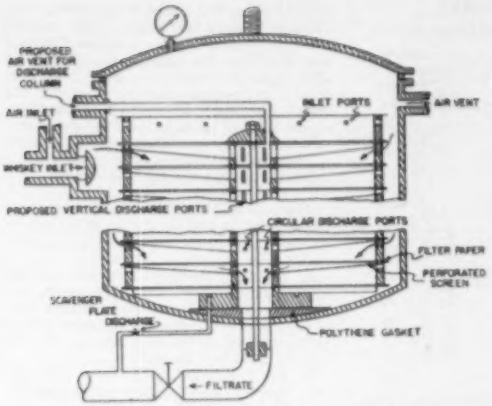

Fig. 4. Sectional View of Horizontal-Plate Filter

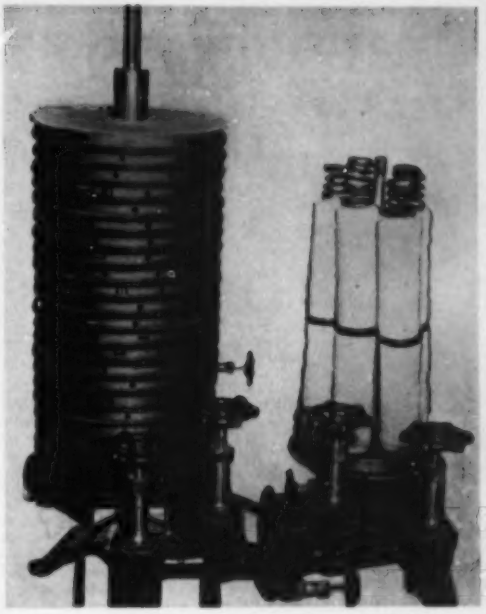

Fig. 5. Plate Assembly of Sealed-Disc Filter, (left). Tube Assembly of Cotton Spool Filter.

ters through holes in the periphery of sludge rings—half the liquid from each ring is then forced through the filter disc underneath it, and half through the filter disc on top of the sludge ring. The sludge rings also serve as a support for the inlet side of the filter disc. The solids are retained in the ring on the surface of the discs. Filtered whiskey from each disc enters directly into the perforated screen next to it, runs through the channels in the screen to the common discharge screen in the center. Approximately 20 sq. ft. of filtration area is available.

Nephelometry (5)

Visual methods of comparison have proved inadequate for reliable development work in whiskey filtration. A horde of variables presents itself which makes it practically impossible to correlate the results consistently. Until recently, even photometric measurement of turbidity was confined to a determination of the light transmitted through a suspension. Determinations become increasingly inaccurate as the turbidity, or light-stopping power of the suspended particles, decreases. Experience has shown that when the scattered light is less than 1% of the transmitted light, more precise measurements can be made by nephelometry (*2*).

"Nephelos" (Greek for cloud) is a term used to describe the ability of a substance to reflect light from within itself. The general term, "turbidity," might in contrast describe only the light stopping power of suspended particles. Whiskey filtrates viewed by transmitted light may appear sparkling clear; however, objectionable cloudiness is often evident by the Tyndall effect. This cloud is potentially dangerous in whiskey since it indicates the probability of delayed precipitation in the product after long standing.

A model *7*, Coleman Photo-Nephelometer was used to evaluate the clarity of whiskey filtrates from the various polishing filters. The instrument was connected to an 8-v. storage battery for greater sensitivity. It is designed to measure the faint cloud of a disperse phase present at concentrations too low for exact measurement of optical density. Instrument response is dependent on particle size and concentration; however, since only the relative determinations of cloud were important the fundamental relationship between instrument readings and absolute concentrations of a Nephelos standard could be ignored. The instrument proved satisfactory for these studies because of its linear response to cloud concentration. Hence it became possible to establish a relative clarity index for whiskey filtrates.

The photonephelometer determines electrically the intensity of scattered light (Tyndall Effect) resulting when an intense, optically controlled beam is

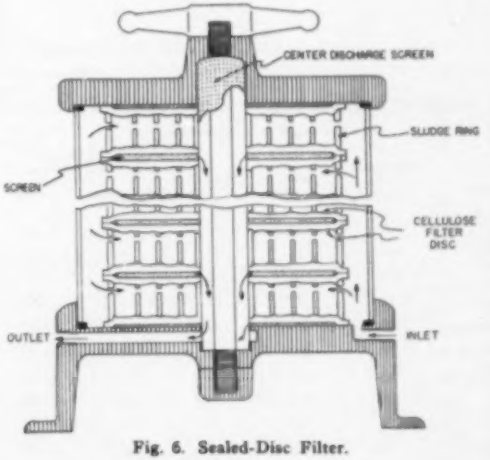

Fig. 6. Sealed-Disc Filter.

TABLE 1.—OPERATING DATA FOR HORIZONTAL-PLATE FILTER

Primary Filtration of Straight Whiskey. Various batches over a 2-month period. Each line of data represents an individual lot.

	Inlet Pressure lb./sq.in.	Pressure Drop lb./sq.in.	Average Rate gal./min.	Total Gallons Filtered (cumulative)
Test No. 1	20	14	116	2,956
	18	9	110	9,608
	23	14	104	19,586
	40	23	92	32,151
	46	37	73.7	48,712
Test No. 2	17	8	105.6	3,326
	23	14	105.6	9,978
	32	23	115	21,619
	38	29	90	28,271
	46	35	55.6	37,532
Test No. 3	19	7	108	1,110
	20	14	108	11,310
	35	14	107	19,116
	27	18	89.5	29,356
	33	24	96.5	41,596
	35	26	91	50,516
	54	36	87.5	68,411

projected through the whiskey sample. Instrument accuracy of 0.2% is possible when the instrument is first adjusted to zero with demineralized water (*3*).

Experimental Procedures

Primary Filtration. Installation of the horizontal-plate filter was checked to be certain that the plates were level. Air connections were added and the entire unit was scrubbed to remove manufacturing soil.

Test 1.—(Table 1). Each plate of the filter was charged with three sheets of filter paper. A sheet of regular alpha-cellulose paper was placed between two sheets of rayon reinforced paper. Previous tests showed them to have no harmful effect on whiskey quality.

The filter was rinsed with demineralized water until no measurable taste was imparted to the discharge.

During filtration, the main discharge valve was opened; the scavenger drain valve was closed, and the air-vent line was closed. (Fig. 4). The first throughput was checked visually for clarity under normal plant procedure. At the conclusion of this test the filter was rinsed with 500 gal. of demineralized water. The total solids removed were determined by weighing the barrel char which accumulated on the plates of the filter. The filter was operated intermittently and composite samples were taken of each dump (approximately 3000 wine gallons) for a visual check of clarity.

Test 2—(Table 1). The filter was cleaned and a test similar to the previous run was made with the following changes:

a. The top plate of the filter was charged with two sheets of rayon paper and three sheets alpha-cellulose paper. One sheet of rayon and one sheet alpha-cellulose paper were placed on each of the other plates.
b. The scavenger-plate drain and air-vent valves were open during the entire filter cycle.
c. Four pounds of Solka-Floc were added at the dump tank as a precoat for the filter. An additional pound was introduced on three occasions during the test run when the inlet pressure of the filter increased abnormally.
d. The filter was blown dry with air after each lot was filtered.

Test 3—(Table 1). The filter was cleaned and charged with filter paper as in Test 1. A check valve was installed in the main discharge line between the valve and processing tank. The air-vent valve was "cracked" open during the entire filter cycle; the scavenger plate drain valve was kept closed until each lot was filtered. After each lot was filtered the main discharge and vent valves were closed and 500 gal. of demineralized water was discharged through the scavenger plate drain.

TABLE 2.—OPERATING DATA FOR HORIZONTAL-PLATE FILTER
(Using Alpha-Pulp for Precoat in Secondary Filtration of Blended Whiskey)

Various Batches over a 3-month period. Each line of data represents an individual lot.

	Pressure lb./sq.in.		Pressure Drop lb./sq.in.	Average Flow Rate gal./min.	Total Gallons Filtered (Cumulative)
	Inlet	Discharge			
Test No. 1	50	40	10	105	7,800
	54	20	34	105	27,400
	50	23	27	111.4	50,800
	52	23	29	120	68,400
	51	23	28	115	86,000
Test No. 2	55	20	35	105	7,800
	51	21.5	29.5	105	39,000
	53	20.5	32.5	100.0	46,800
	51	23	28	100	70,200
	48	22	26	105	97,600
	52	21.5	30.5	100	109,200
	53	21	32	110	123,300
	50	21.5	28.5	100	146,700
	49	20.5	28.5	100	170,100
	51	20	31	95	185,700
	52	23	29	95	209,100
	51	21.5	29.5	100	224,700
	55	28	12.0	90	248,100
	52	21	31	90	271,500
	55	20	35	90	310,500

Secondary Filtration

Test 1—(Table 2). The 12-plate horizontal filter was installed in parallel with pulp-pad filters between the processing and bottling tanks at the Seagram plant at Louisville, Kentucky. A small slurry tank and pump were connected to the inlet line of the filter for use in precoating. Each plate of the filter was charged with two sheets of rayon filter paper. The filter was precoated with a slurry of Solka-Floc (5 lb. to 150 gal.).

One pound of Solka-Floc was added to the processing tank as a "body treatment" before each lot of whiskey was filtered. The air-vent valve was open during the entire cycle; the scavenger plate drain was closed until the end of each run. The whiskey filtrate was recirculated until the clarity was satisfactory. A portion of each lot was filtered through the pulp-pad filters and samples were taken for clarity comparison.

Test 2—(Table 2). The filter was cleaned and each plate was charged with paper as previously described in primary filtration (Test 1). A precoat of 20 lb. of Solka Floc was used as a body treatment for each lot filtered.

Bottling Line Filtration. Preliminary studies in laboratory and plant showed that sealed discs having a high asbestos content were unsatisfactory for whiskey filtration. Several high alpha-cellulose papers containing varying percentages of asbestos (0-30%) were then selected.

TABLE 3.—LABORATORY EVALUATION OF FILTER PAPER FOR SEALED-DISC FILTER
(Using Photonephelometer)

Filter Paper	Filtering Time (sec.)	Klett Color	Tyndall Index	Nephelometer Bal Reading		Relative Clarity Index
				Maximum	Average	
Composite sample, not filtered		154	10	6.00	4.18	10
Alpha-cellulose, 30% asbestos	240	67	10	7.80	5.35	14
Alpha-cellulose, wood pulp	210	162	4	4.96	3.30	7
Alpha-cellulose, 23% asbestos	25	71	10	7.60	6.21	13
Alpha-cellulose, (wood), asbestos-free	15	152	4	4.80	3.67	8
Alpha-cellulose, (wood), asbestos-free	30	153	4	5.20	3.87	9
Alpha-cellulose, (rag), asbestos-free	20	152	6	5.55	3.73	9
Alpha-cellulose, 5% asbestos	20	149	6	5.85	5.00	10
Alpha-cellulose, 5% asbestos	5	147	5	3.83	3.55	6
Alpha-cellulose, 20% asbestos	70	115	4	1.68	1.36	3

To evaluate the relative clarity of filtrates through various papers the following procedure was devised:

a. A composite sample of blended whiskey from the bottling tank was used as the unfiltered standard.
b. Eight ounces of the unfiltered standard were filtered once through 5-in. circles of each paper tested, using a Büchner funnel with 26-in. Hg. vacuum. Filtering time was recorded.
c. Various filtrates were compared visually with the unfiltered composite by an incident beam of light at 90°. A Tyndall index was arbitrarily selected for each sample as shown in Table 3.
d. In each case the entire filtrate was checked in the photonephelometer. Maximum and average BAL readings were taken. A relative clarity index was established by multiplying the maximum readings by a factor (1.67).
e. The color was checked with a Klett-Summerson colorimeter; a No. 54 green filter was used.

Plant trials were conducted on the basis of laboratory results. The sealed-disc filter was charged with Seitz alpha-cellulose, 20% asbestos (*G-P*) paper in parallel with a cotton-spool filter on a bottling line at the Lawrenceburg (Ind.) plant. Operating data on this test are summarized in Table 4. Samples were taken before and after filtration through both filters. BAL readings of the entire sample were determined on the photonephelometer and recorded as shown in Table 5.

Samples, before and after filtration through a modified stone filter at Louisville, were likewise checked using the photonephelometer.

TABLE 4.—OPERATING DATA FOR SEALED-DISC FILTER

(Using Alpha-Cellulose (20% Asbestos) Paper for Polishing Filtration of Blended Whiskey)

Pressure lb./sq.in.		Pressure Drop	Average Flow Rate	Total Gallon	Klett
Inlet	Discharge	lb./sq.in.	gal./min.	Filtered	Color
20	4	16	17	.....	160
23	13	10	....	.....	...
22	13	9	....	12,513	...
25	7	18	17.5	.....	...
19	4	15	....	25,612	155
30	5	25	18.0	27,028	157
31	3	28	24.0	.....	...
38	4	34	....	39,937	155
34	8	26	18.0	.....	...
31	4	27	....	56,652	157
35	5	30	20.9	.....	...
30	2	28	....	75,379	156
42	11	31	....	.....	...
32	4	28	20.6	86,284	152
30	5	25	....	.....	...
28	9	19	23.0	97,552	157
24	2	22	23.0	103,652	161
28	11	17	....	.....	...
31	2	29	23.0	119,957	150
33	14	19	....	.....	...
33	11	22	24.0	142,138	160
28	16	12	....	.....	...
33	8	25	23.5	162,186	157
31	10	21	....	.....	...
34	10	24	24.0	182,647	160

Experimental Results

Primary Filtration

Test 1—(Table 1). Intermittent flow to the filter, and poor venting of air from

TABLE 5.—RELATIVE CLARITY OF FILTRATES—PLANT TRIALS

(Polishing Filtration of Blended Whiskey)

	Unfiltered Sample from Bottling Tank		Cotton-Spool Filter		Stone Filter		Sealed-Disc Filter			
Filter media	.....	.....	1746 *CT* Tube		No. 20 Permeability Stone		α-Cellulose 5% Asbestos		α-Cellulose 20% Asbestos	
Klett color	156	162	142	150	154	159	160	159	146	150
Bal reading (Photonephelometer)	4.20	4.00	2.20	1.50	1.30	2.10	0.90	1.95	0.75	0.55
	4.90	4.50	2.80	1.90	1.85	1.85	1.15	2.25	0.65	0.10
	5.85	4.75	2.35	2.15	3.90	1.60	1.70	1.95	1.60	0.15
	5.45	4.50	1.95	2.45	3.45	2.20	1.45	2.50	1.00	0.30
	4.65	4.25	1.50	2.35	1.60	1.95	1.60	1.75	0.90	0.00
	4.75	4.20	1.20	2.10	2.70	3.05	1.85	2.25	1.15	0.10
	5.20	4.20	1.15	1.45	2.05	5.10	1.75	1.85	0.90	0.05
	4.80	4.60	1.30	2.00	2.20	2.05	1.45	2.20	1.00	0.10
	5.10	5.15	1.45	2.20	3.60	6.95	1.90	1.80	1.05	0.15
	4.80	4.90	1.65	2.05	2.20	6.30	1.70	1.80	1.15	0.35
Bal reading-average	4.98	4.53	1.76	2.22	2.50	3.32	1.55	2.13	0.95	0.19
Bal reading-maximum	5.85	5.15	2.80	2.35	3.90	6.95	1.90	2.25	1.15	0.55
Relative clarity index	100	88	48	57	67	119	33	36	18	9

TABLE 6.—COMPARATIVE OPERATING DATA FOR VARIOUS WHISKEY FILTERS

Type	Use	Cost/M Wine Gallons (cents)			Filtering Area (sq.ft.)	Total Gallons Filtered	Average Flow Rate (gal./min.)	Pressure Drop lb./sq.in.	
		Material	Labor	Total				Start	End
Vertical Screen Filter, Pulp Filter in Series	Primary Filtration of Straight Whiskey—	1.07 35.00	6.63 5.89	7.70 40.89	45.0 75.0	10,000 90,000	80.0 80.0	5 18	20.0 34.0
		36.07	12.52	48.59	120.0				
Horizontal—Plate Filter	Removal of Barrel Char	10.27	2.57	12.84	65.0	51,550	101.5	8	35.0
Pulp filter—(2) in Parallel	Secondary Filtration of Blended Whiskey	25.20	3.18	28.38	150.0	250,000	107.0	18	42.0
Horizontal—Plate Filter		10.24	0.67	10.91	65.0	198,250	101.40	10	35.0
Stone Filter	Final "Polishing" Filtration of Blended Whiskey	5.53	1.36	6.69	4.5	100,000	23.0	2.0	35.0
Cotton-Spool Filter		7.56	0.68	8.24	5.25	100,000	23.0	5.0	.....
Sealed-Disc		2.77	0.75	3.52	20.31	182,647	19.2	9.0	31.0

TABLE 7.—SUMMARY OF OPERATING CHARACTERISTICS FOR VARIOUS WHISKEY FILTERS

Purpose	Filter Arrangement	Advantages	Disadvantages
Primary Filtration (Removal of barrel char)	Vertical-screen, pulp-pad filter in series	1. Long filtering cycle 2. Good clarity	1. Limited capacity for char 2. High cost of pulp pads 3. Filter must be "proofed" 4. High pressure drop causes by-passing
	Horizontal Plate Filter	1. High flow rate 2. Negligible losses 3. Rayon paper prevents by-passing 4. Simplicity—minimum floor space 5. Low operating cost	1. Scavenger plate becomes overloaded
Secondary Filtration	Pulp-pad filter (9)	1. Excellent clarity 2. Long filtering cycle	1. High cost of pulp pads 2. High pressure drop causes breakdown of media 3. Low flow rate
	Horizontal-plate filter	1. High flow rate 2. Rayon paper prevents by-passing 3. Minimum floor space 4. Low operating cost	1. Filter aid required 2. Careful control of air venting required
Final Polishing Filtration	Cotton-spool filter	1. High flow rate 2. Minimum floor space	1. Whiskey losses 2. Relatively high cost of filter tubes 3. High pressure drop causes by-passing
	Stone filter	1. High flow rate 2. Durable media	1. Stones become difficult to clean effectively
	Sealed-Disc filter	1. Excellent clarity 2. Long filtering cycle 3. Low operating cost 4. Minimum floor space	1. Slight whiskey loss

the filter caused uneven distribution of char on the plates. Alpha-cellulose paper broke on the top plate, but the rayon paper prevented char from entering the discharge.

Test 2—(Table 1). Filter aid was found undesirable for removing barrel char from whiskey because the scavenger plate became filled with filter aid and caused a poor plate seal.

Test 3—(Table 1). First, fourth, and eleventh plates showed penetrations of char through the top rayon sheet. Apparently, the rayon paper affords wet strength only to the filter media. Here again the scavenger plate tended to fill with solids, indicating faulty distribution of whiskey to each plate. Total solids removed averaged 100-120 lb. for each test run.

Secondary Filtration

Test 1 (Table 1). Four barrels of unfiltered whiskey were added to the processing tank and the char removed without difficulty. The test run was discontinued (Table 2) after the final lot in Test 1 was filtered. Filter aid contaminated the filtrate when excessive "air binding" on the plates caused a break in the seal. It was found necessary to provide a special air vent (Fig. 4) for the discharge column. Residual whiskey was removed almost entirely at the end of the filtering cycle by subjecting the filter to 10 lb./sq.in. air pressure for 15 min.

Test 2 (Table 2). Installation of an air vent for the discharge column (Fig. 4) on the experimental filter made it possible to obtain a total flow cycle of more than 300,000 wine gal. (Table 2, Test 2).

Bottling Line Filtration. No clarity problems were observed by normal line inspection during the test run of the sealed-disc filter at Lawrenceburg (Table 4). The filtering cycle was almost twice as long (182,647 total gallons filtered) as that of the spool filter. The pressure drop across the filter ranged from 9 to 24 lb./sq.in. Color of the filtrate did not vary appreciably.

Results of photonephelometer readings on samples taken during the plant trials establish the superiority of the sealed-disc filter (Seitz alpha-cellulose paper) as shown in Table 5. The plant results confirm data from pretesting in the laboratory.

Conclusions

A summary of operating data is presented in Table 6, covering filter equipment for each of the three steps in whiskey filtration. Operating costs, for material and labor, of the horizontal-plate filter are lower than those of existing equipment. Superiority is further established by the high flow rates obtained. Whiskey losses become negligible and the filtering equipment is simplified greatly to permit more careful control of the operation. For plant use, 17-plate filters were selected, incorporating design modifications as shown in Figure 4. These were:

a. Installation of a baffle in the inlet line and raising the inlet ports to the top of each plate to permit better distribution of whiskey on the plates.
b. Air vent located below the cover on the filter shell speeds up cleaning and assembling of the filter.
c. Slotted discharge ports and a separate air vent for the discharge column are suggested to minimize air-binding on the plates.
d. Polyethylene gaskets, which are comparatively inert to whiskey, are used to replace conventional rubber gaskets.

The sealed-disc filter, using Seitz alpha-cellulose, 20% asbestos (*G-P*) paper, produces an extremely clear whiskey when installed as a polishing filter on the bottling lines. The operating cost of this filter is lower than either the stone or cotton-spool filters because of the increased whiskey throughput before cleaning is necessary.

For plant use, it is recommended that the Seitz *K*-5 paper be used for whiskey filtration. This medium has the same pore size (1-2μ) as the *G-P* paper and less asbestos content (15%). It is desirable, also, to equip the filter with an internal, plate seal to promote better compression when the thickness of the filter paper is variable.

Acknowledgment

The authors acknowledge the helpful suggestions and criticism of M. C. Brockmann, W. B. Altsheler, and E. G. Capstack. They are also grateful to P. Burd and H. Hirt for assistance in the plant experimental work.

Literature Cited

1. Baker, R. H., and Barkenbus, C., *Ind. Eng. Chem.*, **29**, 755 (1937).
2. Gibbs, T. R. P., Jr., "Optical Methods of Chemical Analysis," McGraw-Hill Book Co., New York (1942).
3. Manufacturers of the various equipment.
4. Schmitt, R. O., Kolachov, P. J., and Willkie, H. F., *Ind. Eng. Chem.*, **34**, 1135 (1942).
5. Yoe, J. H., and Kleinman, H., "Photometric Chemical Analysis," II, John Wiley and Sons, New York (1929).

Presented at Twelfth Regional Meeting, Montreal (Que.), Canada.

BOSTON MEETING TO FEATURE ULTRASONICS AND FLUIDIZATION

By

J. N. ADDOMS

MID-CENTURY finds the American Institute of Chemical Engineers returning to Boston May 28-31 to discuss topics and techniques unknown to chemical engineers who attended the first Boston meeting in 1913. As the Institute grew, Boston served as host for meetings in 1919, 1931 and 1942. Headquarters this year will be the New Ocean House, located in Swampscott on Massachusetts' North Shore.

The program of technical papers forms the vehicle which justifies and supports this get-together of chemical engineers, and the Papers Committee consisting of Co-Chairmen R. L. Geddes and E. R. Gilliland assisted by Margaret Hutchinson and Dudley Thompson is providing a program of broad interest which is expected to draw a large attendance. All the technical meetings will be held in the same gathering place without duplicating sessions; conducive to a homogeneous atmosphere where it will be easy to meet friends at informal moments. This atmosphere will prevail at the evening panel discussions of current chemical engineering problems and trends to be led by officers and directors of A.I.Ch.E.

Special features for the lighter side of the program include an informal mixer to begin the proceedings on Sunday evening, an old-fashioned barn dance, good New England food, tours of the many points of historical interest, and convenient sports facilities.

Ultrasonics Symposium

The Symposium on Ultrasonics will consist of seven papers presented at two sessions on Tuesday, May 30, and will be under the supervision of Dudley Thompson, department of chemical engineering, Virginia Polytechnic Institute, Blacksburg, Va. The purpose of the Ultrasonics Symposium is threefold: (1) to establish potentialities of this relatively new tool of science, (2) to ascertain its limitations, and (3) to stimulate more extensive and intensive investigations of the phenomena that may be produced by it.

Two papers will deal with sonic energy in the process industries. E. P. Neumann of MIT and the Ultrasonic Corp., Boston, will consider fundamental concepts. C. A. Stokes, Godfrey L. Cabot, Inc., Boston, and J. E. Vivian, department of chemical engineering, MIT, will consider the industrial applications of ultrasonics.

Three papers will deal with the effects produced by ultrasonics. Alfred Weissler, Naval Research Laboratory, Washington, D. C., will consider the physicochemical effects of ultrasonics; and Karl Sollner, National Institute of Health, Bethesda, Md., will discuss the colloidal effects of ultrasonics.

Two papers will be concerned with matter and materials. J. C. Hubbard, department of physics, Catholic University, Washington, D. C., will present a paper on ultrasonics in the study of matter. Benson Carlin, Smith-Meeker Engineering Corp., New York, N. Y., will discuss material testing and gaging with ultrasonics.

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Officers of General Committee for Boston Regional Meeting. Left to right: John J. Healy, Jr., Monsanto Chemical Co., general chairman; Arthur J. Good, E. B. Badger and Sons Co., secretary; Neal A. Sargent, Monsanto Chemical Co., treasurer; J. Donovan, Artisan Metal Products, vice-chairman.

Left to right: Mrs. C. P. Baker, John J. Healy, Jr., general chairman, and Mrs. John J. Healy, Jr., discussing the ladies' program for the Boston Regional Meeting, which will feature tours of Lexington and Concord, a barn dance, and a boat trip to Gloucester.

Three charter members of the Ichthyologists, G. J. Esselen, H. J. Skinner, and A. L. Gardner at a recent local section meeting of Boston group.

Plans for hospitality being made by J. Donovan, vice-chairman, General Committee; C. A. Stokes, chairman, Hotels Committee, and W. B. Parker, chairman, Hospitality Committee.

BOSTON MEETING

(*Continued from page* 13)

Fluidized Powder Operations

The session on Fluidized Powder Operations consisting of five papers, will be presided over by E. R. Gilliland. The purpose of this group of papers is to emphasize the chemical reaction aspects of the fluidized powder process rather than the physical characteristics of the operation.

A paper by E. L. Piret, R. A. Ebel, C. T. Kiang and W. P. Armstrong of the division of chemical engineering, University of Minnesota, will deal with diffusion rates in porous solids with particular emphasis on the effects encountered with porous catalysts.

Experimental results of the flow of a gas and solid in a commercial catalytic cracking unit will be presented by J. W. Askins, G. P. Hinds, Jr., and Fred Kunreuther of Shell Oil Co., Inc.

Two papers will deal with the mechanism of chemical reactions in beds of fluidized powders. W. K. Lewis, E. R. Gilliland and D. E. Boynton will present data on the reaction of various iron oxides with carbon monoxide, hydrogen, and methane, and the second paper by W. K. Lewis, E. R. Gilliland and M. P. Sweeney will consider the oxidation of solid carbon by metal oxides.

General Papers. There will be about ten papers in the general technical sessions. A paper by C. M. Sliepcevich and G. G. Brown of the University of Michigan deals with the design of a continuous, small scale plant for studying catalytic reactions at pressures as high as 10,000 lb./sq.in. and temperatures as high as 1200° F., and includes original data on the dehydration of butanol-1.

A contribution from Oklahoma A. & M. College will be a paper on the extraction of cobaltous chloride with capryl alcohol in spray towers. This paper, prepared by Leo Garwin and R. L. Kylander, indicates an improvement in the process of separating cobalt and nickel, whose similar properties have presented difficulties to the metallurgy industry.

N. C. White of the International Minerals and Chemicals Corp., Carlsbad, N. M., will discuss the important potash industry of this country on which little information has hitherto been made public. This industry utilizes such operations as crystallization, evaporation and flotation.

Of particular interest to both administrative engineers and young employees will be a paper prepared by a firm of psychologists with a successful record as consultants to industrial and business organizations. The paper, "Training and Selection of Engineers," by Arthur L. Miller and Paul Miller, will deal with their experience in the testing and proper placement of engineers.

D. Q. Kern, of Patterson Foundry and Machine Co., will give the results of an investigation made in collaboration with C. Leroy Carpenter, of Colgate-Palmolive-Peet Co., on the treatment of temperature difference in split flow heat exchangers. With the results of the present study, it is possible to handle the process design of these low pressure drop exchangers with the desired accuracy.

General papers contributed by the Massachusetts Institute of Technology will include one by Alan S. Michaels on the kinetics of ion exchange in fixed beds, and another by H. P. Meissner and R. Seferian on a new P-V-T correlation. Professor Michaels will describe recent work on the effect of liquor velocity and bed height on the rate and efficiency of sodium-hydrogen exchange in beds of the resin, Nalcite HCR. Professor Meissner will discuss how some inaccuracies resulting in the use of present correlations of compressibility factors may be avoided by use of a new graphical technique.

During the three-day meeting there will be several evening discussions of current chemical engineering trends and problems. W. L. McCabe of Flintkote Co. will lead a discussion on "New Fields for the Chemical Engineer." T. H. Chilton of the Du Pont Co. has chosen "Research Methods in Unit Operations" as his topic. Liaison be-

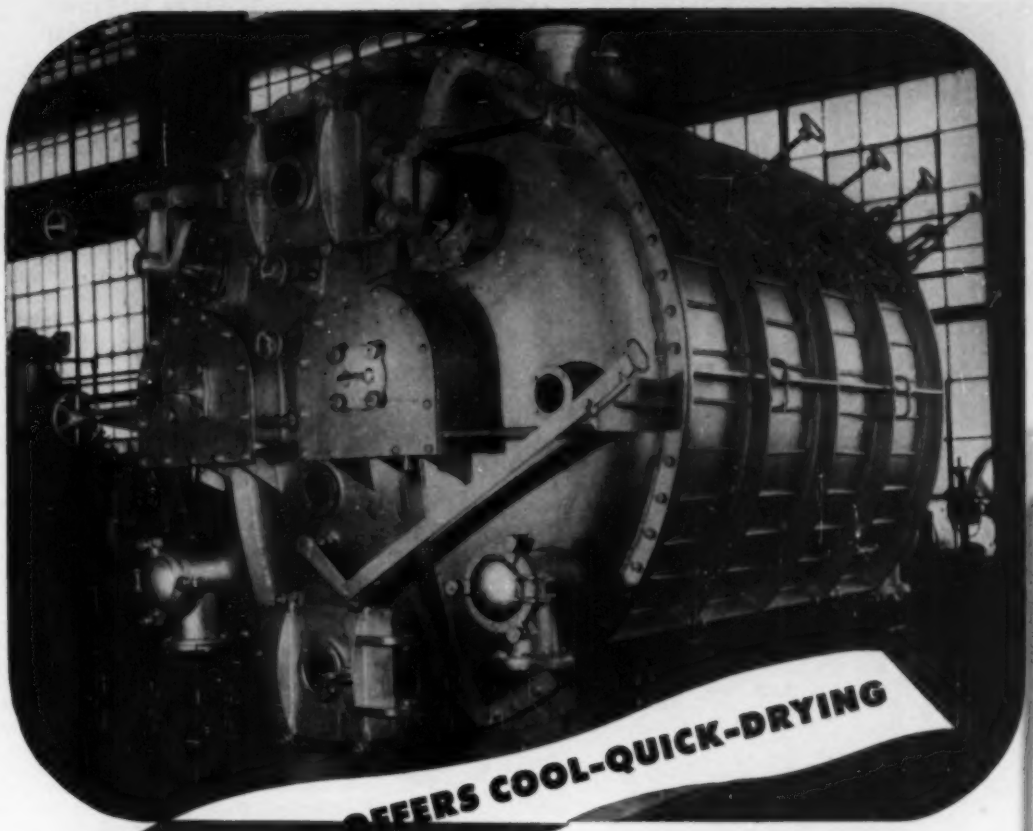
(*Continued on page* 16)

NOTE OF WARNING

You'll meet all kinds of Fish at the Boston meeting, Kingfish, Mackerel, Smelt, Shark; these are the officers of the Ichthyologists, known more formally as the Boston Section of A. I. Ch. E. The Ichthyologists began when the committee chairmen for the 1931 Boston meeting decided to continue their monthly get-togethers as a social affair. With meetings held on Fridays there inevitably arose discussion of the main course for dinner. Fish usually won out, and when Robert Weston came out with, "This is a bunch of Ichthyologists, not chemical engineers," the organization had its name.

In 1935 the Ichthyologists became the Boston Section of A. I. Ch. E., after careful investigation showed that the merger would involve no money, but only the drafting of by-laws. Unique in the annals of the Institute, the by-laws provided that "the order of business shall be varied so as not to get monotonous" and that honorary membership be conferred on anyone "buying one round of refreshments for the members present at any regular meeting."

Come prepared, then, to meet these Ichthyologists who will welcome you to Boston in May. Of course, new honorary memberships will be accepted at the meeting.



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BOSTON MEETING

(*Continued from page* 14)

tween research and engineering will be debated under the leadership of W. T. Nichols of Monsanto Chemical Co. Education of chemical engineers for industry will be discussed by W. G. Whitman, MIT.

Plant Visits

The list of plants provides a cross section of the varied New England chemical industries: A. C. Lawrence Leather Co., A. D. Little, Inc., National Research Corp., Boston Woven Hose Co., Monsanto Chemical Co., Gillette Safety Razor Co., Eastern Gas and Fuel Associates, Revere Sugar Co., and G. E. Co.

Ladies' Program

Mrs. J. J. Healy, Chairman of the Ladies Committee, extends this word of welcome: "There will be opportunities for observing the locale where our national history had its beginnings, for treading the ground made famous by 'The Peabody Sisters of Salem,' for sailing the water which cradled the Clipper Ships and for inhaling the rarefied atmosphere of Fair Harvard, Radcliffe, and MIT. The ladies of the Boston Section Committee anticipate welcoming their visitors and trust that the atmosphere of informality and true sociability will remain as a pleasant recollection of this New England meeting."

Events which have been planned especially for the ladies include a book review on Monday morning. In the afternoon Dr. and Mrs. Fisher will be hosts for tea in their historic home to all those taking the tour of Concord and Lexington. Tuesday morning an ocean voyage to Gloucester and Salem will provide an invigorating exploration of the North Shore. In the evening there will be a typical old-fashioned New England barn dance, with an excellent caller and orchestra as well as a small trained group to demonstrate and lead sets.

Wednesday morning a tour of Cambridge will provide an opportunity to visit the universities and the world-famous glass flowers. Mr. and Mrs. Donovan will be hosts for coffee on the return trip.

Hotel Facilities. Sports facilities will include golf, tennis, swimming and sun bathing on the beach.

A novel feature of the meeting is the provision for a premeeting week-end holiday at the delightful Swampscott beach resort. Rooms are available for members and wives at the New Ocean House the Friday before the meeting. Requests for reservations can be made direct to the hotel using the cards that will be mailed out for this purpose.

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HOUSTON REGIONAL MEETING

TEXAS ALLOWS OUTSIDERS TO BRAG

R. A. BENZAQUIN

TEXANS, famous the world over for their love of hyperbole, extended their generous hospitality to allow out-of-state chemical engineers to display their accomplishments at the Houston Regional Meeting of the A.I.Ch.E., Feb. 26-March 1, 1950. Nearly all technical papers presented at the meeting, by coincidence, were by non-Texans.

More than 800 chemical engineers attended the meeting and this figure closely rivals the existing attendance records for Institute regional meetings which occurred in Cleveland about two years ago. Some two-thirds of the attendance were Texans while the remainder were the bragging outsiders. The fact that nearly 300 out-of-state chemical engineers traveled the distance necessary to attend the meeting in Houston is evidence of the interest currently being expressed by engineers in the chemical industry of the Houston area.

A feature of the Houston meeting were its "Bull Sessions" on several different topics of importance to the chemical engineer: Training of Plant Supervisors, Chemical Plant Surface Protective Coatings, What's News, Relation Between Universities and Industries—Educating and Training Chemical Plant Technical Personnel, and Chemical Plant Safety. The bull sessions were informal discussion groups, of forty to sixty, with everyone free to speak openly on his pet theories. A "chief bull shooter" was on hand at each session to catalyze the discussion, but the reactions once initiated readily became self-sustaining, generating much light and in some cases no little heat.

W. A. Cunningham, University of Texas, general chairman, Houston Regional Meeting.

Technical Program

The technical program opened with a Symposium on Phase Equilibrium with nine papers being presented in morning and afternoon sessions. This symposium is a continuation of the one presented at the Pittsburgh Annual Meeting in 1949. The symposium will be concluded with several additional papers at the Minneapolis Regional Meeting to be held in September, 1950. W. C. Edmister, Carnegie Institute of Technology, has been responsible for programming this symposium.

O. Redlich, A. T. Kister and C. Turnquist of Shell Development Co. in their paper, "Thermodynamic Analysis of Vapor Liquid Equilibria," presented their evaluation of the most practical and direct methods of solving vapor-liquid equilibrium problems involving complex mixtures. Binary data may be used to define equilibrium conditions in multicomponent mixtures with accuracy. Considered use of the thermodynamic tools at hand should be made before attempting the arduous task of obtaining experimental equilibrium data of doubtful accuracy on multicomponent systems. The authors also proposed an equation of state of the van der Waals form.

Three papers were given describing equilibrium systems useful in the extractive distillation separation of C_4 hydrocarbons. J. Griswold, R. V. West and K. K. McMillin of the University of Texas obtained correlations on conjugate-phase data in terms of activity coefficients on furfural-hydrocarbon systems by a single relation applicable for all water concentrations from 75° to 200° F. The correlations, the authors stated, have been useful in the prediction of the appearance of water and hydrocarbon phases in the furfural solvent columns of butadiene plants.

"Extractive Distillation Separation of *n*-Butane from Butenes-2," a paper by H. V. Hess, E. A. Naragon and C. A.

(*Continued on page 20*)

S. L. Tyler, Secretary, A.I.Ch.E., and C. L. Parsons, former Secretary, A.C.S.

Committee members responsible for success of Houston Meeting: C. L. Dickinson, Diamond Alkali Co.; William Kaplan, Pan American Refining Corp.; J. D. Lindsay, A & M College of Texas; W. A. Cunningham, University of Texas; W. W. Akers, Rice Institute; Mrs. C. M. Hickey, Ladies' Committee; B. I. Thorngren, Maintenance Engineering Corp.; R. N. Blaize, Eastern States Petroleum, Inc.; A. A. Draeger, Humble Oil & Refining Co.; James A. Lee, "Chemical Engineering."

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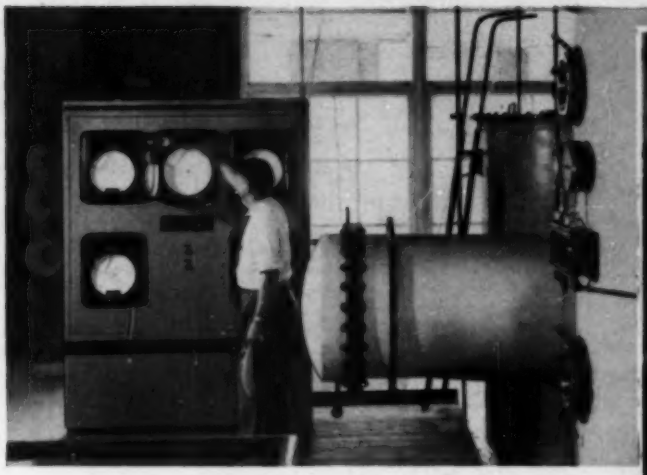

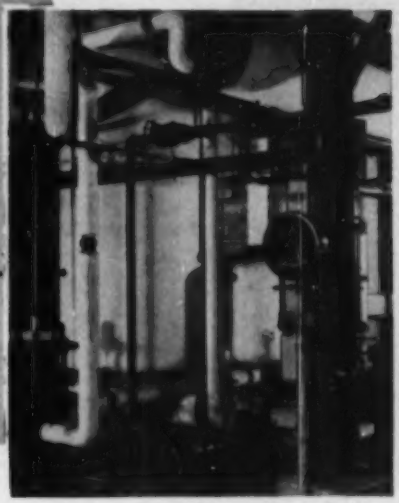

Promising to pay for itself in less than a year through new, over-all economies, this fully automatic Foxboro Cabinet Control System is giving precise, round-the-clock operation of Zaremba Evaporators at the American Thread Company's Kerr Mill, Fall River, Mass. *At right* — on the floor below, a Foxboro Indicator transmits thin liquor flow measurement to cabinet-mounted recorder.

A New Opportunity to Modernize Another Important Chemical Process

Accurate, coordinated control of variables, by means of this Foxboro development, improves evaporating efficiency four ways: (1) it increases evaporator capacity, saving time and money; (2) it releases manpower from purely routine duties; (3) it eliminates the inaccuracies of spot sampling; (4) it assures uniformly concentrated end-product.

If you have, or are planning a process involving evaporation, why not investigate the advantages offered by fully automatic Foxboro control? Ask your nearby Foxboro Field Engineer for further information, or write **The Foxboro Company, 248 Neponset Ave., Foxboro, Mass., U. S. A.** Branches in principal cities.

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5 OUTSTANDING FUNCTIONS of the control system shown above

1. *continuously records and controls by electronic comparison of solution's boiling point to boiling point of water at the same pressure . . . and automatically adjusts steam input as required. This is an original Foxboro system, known as "boiling point rise" control —*

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5. *automatically diverts these to sewer if contamination rises above safe limits.*

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Process-Improving Controls
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HOUSTON MEETING

(*Continued from page 18*)

Carl F. Prutton, Mathieson Chemical Corp.

Dudley Thompson, Virginia Polytechnic Institute.

C. P. Roberts, Food Machinery & Chemical Corp., winner of the Institute Award for best presentation of any paper on Houston technical program.

W. D. Kohlins, Buflovak division, Blaw-Knox Co.

C. F. Hauck, Hall Labs.

R. B. MacMullin, R. B. MacMullin Associates.

Coghlan, Beacon Laboratories of the Texas Co., related an account of the researches to discover the most suitable extractive distillation solvent for the separation of *n*-butane from butenes-2. Some 11 different classes of organic compounds, nearly 90 in all, were tested for their selective action, equilibrium determinations being made at 60 lb./sq. in. Of the many compounds tested, furfural, aniline, methyl acetoacetate, acetonitrile and phenol when modified with water gave good selectivity. Aniline and furfural showed sufficient advantages for further study, and additional data are now being obtained on a pilot plant scale, it was disclosed.

The third contribution on C_4 hydrocarbon equilibria was "Vapor-Liquid Equilibrium of C_4 Hydrocarbon-Furfural Water Mixtures by D. Jordan, J. A. Gerster, K. Wohl and A. P. Colburn of the University of Delaware.

A method for calculating the conditions for equilibrium flash vaporization and true boiling-point curves of the products was presented by W. C. Edmister, Carnegie Institute of Technology, and J. R. Bowman, Mellon Institute. Flash vaporization finds common application in petroleum industry separations.

Another paper in the Phase Equilibrium Symposium was "Low Temperature Equilibrium," by G. M. Brown, Northwestern Technological Institute. A correlation was developed for equilibrium constants for hydrogen and helium in binary and multicomponent systems applicable in the temperature range 100° R. to 1000° R. and for pressures up to 10,000 lb./sq.in.

Dudley Thompson, Virginia Polytechnic Institute, presided over the Symposium on Ultrasonics and Waste Disposal. The papers on ultrasonics presented at the Houston meeting were a preview of a more complete ultrasonics symposium to be held at the Swampscott, Massachusetts meeting in May of this year. This symposium, which has been organized by Mr. Thompson, will provide further insight into the possibilities of this new process tool which has already found application in fine-particle agglomeration in dust- and mist-removal systems. H. W. Danser, Jr., reviewed developments and installations in the collection of dusts and mists by sonic means.

The sonic generators described in Mr. Danser's paper were compressed air sirens.

W. H. Janssen, General Electric Co., in his paper discussed electrical means of producing energy at ultrasonic levels with particular reference to piezoelectric materials such as quartz and a new material barium titinate. Barium titinate is a ceramic material which can be produced in practically any size or form and which exhibits the properties of a single piezoelectric crystal, even though it is not a homogeneous material but composed of many tiny crystals.

"Industrial Water Management" is the name given by C. F. Hauck of Hall Laboratories to the comprehensive programs, which are becoming necessary in many chemical and processing plants for the economic use and disposition of water. Today, he said, there are few water users who cannot profit by a complete study of the water flow sheet employed in their process by the most com-

(*Continued on page 22*)

H. D. Wilde and J. L. Franklin, Humble Oil & Refining Co., members, Committee on Arrangements; W. P. Schambra, Dow Chemical Co., "Chief Bull Shooter," Bull Session on Plant Protective Coatings.

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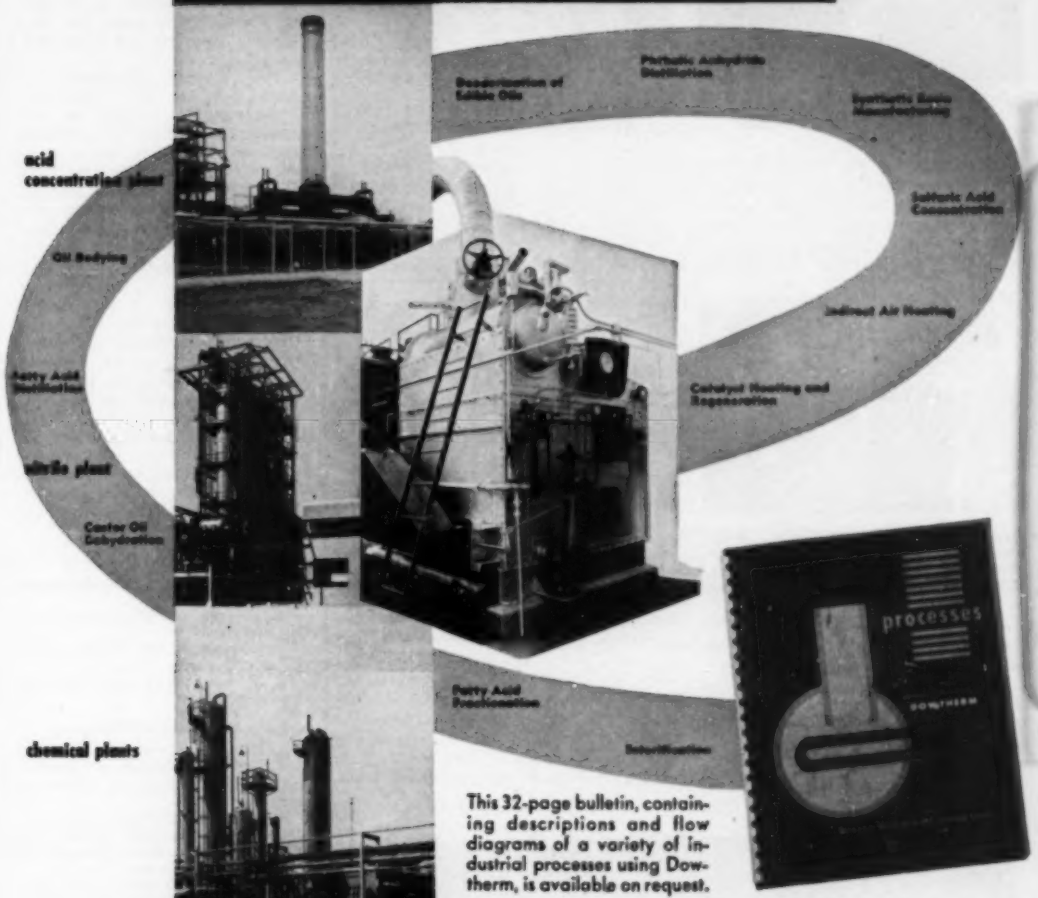

This 32-page bulletin, containing descriptions and flow diagrams of a variety of industrial processes using Dowtherm, is available on request.

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FOSTER WHEELER

HOUSTON MEETING

(*Continued from page 20*)

W. K. Lewis, M.I.T., and Warren L. McCabe, President, A.I.Ch.E.

W. V. Houston, President, Rice Institute, principal banquet speaker.

petent engineers. He emphasized that this study must be thorough, tracing the cause of many unsatisfactory installations of water systems to a misunderstanding of all the factors involved. These factors can have technological, economic, legal and public relations aspects.

Following Mr. Hauck's talk was a paper by W. D. Kohlins and E. L. Demarest of the Blaw-Knox Co. on specific methods and case histories of waste disposal problems which were turned into profitable, or at the very least self-amortizing programs. The waste disposal programs as described by Mr. Kohlins, who presented the paper, involved the evaporation of the effluent stream thus effecting concentration of the waste to a saleable or readily disposable form. In one particular case cited, the disposal of fish stick-water, a foul smelling high B.O.D. waste from the oil pressing of menhaden, necessitated the installation of an evaporator plant costing roughly $300,000. The concentrated waste resulting from one

(*Continued on page 37*)

Authors of student papers: Ralph Somers, Texas A & M.; J. C. Counts, University of Texas; G. R. Walton, Jr., Rice Institute, and E. L. Britt, Texas A & M.

Phase Equilibria Symposium speakers: H. V. Hess, Texas Co.; O. Redlich, Shell Development Co.; R. V. West, University of Texas; J. A. Gerster, University of Delaware; W. C. Edmister, Carnegie Inst. of Tech., and W. A. Gleich, University of Rochester.

W. E. Alexander and P. S. Buckley of Monsanto Chemical Co., members of Hospitality Committee. Registration Committee: seated, V. L. Keldsen, Shell Chemical Corp.; J. M. Andrews, Humble Oil & Refining Co.; R. Stiffler, Rohm & Haas and Monty Estrada; standing, W. J. Butler, Diamond Alkali Co.; D. P. Delavan, Southern Acid & Sulphur, and C. L. Dickinson, Diamond Alkali, committee chairman.

DIVISIONS FOR A.I.Ch.E.?

A movement was started at the Houston Regional Meeting of the Institute for the establishment of a Technical Data Division.

The idea came out of an evening "bull session" on Phase Equilibria, attended by about 40 of the more interested and rugged of those who had attended the full day's program on the same subject.

Such a division would have two objectives: (1) to plan and hold special programs of papers on subjects of interest to division members, (2) to make and distribute preprints of division's papers.

Prof. Wayne C. Edmister, Carnegie Institute of Technology, Pittsburgh, Pa., agreed to determine the number of chemical engineers interested, and a committee consisting of Robert Ray, M. J. Rzasa, and F. W. Winn was appointed to help develop the proposed division. All those interested in participating should write Professor Edmister.

Editor's Note: The Program Committee, under the Chairman, George E. Holbrook, has been developing plans for dividing the Program Committee into several divisions with the thought that they might eventually form the basis for the broad divisions within the Institute. At present the Program Committee members are being asked to comment on the following suggestions relative to divisions:

Suggestion No. 1

a. Research and Development Division
b. Process and Equipment Design Division
c. Operation and Technical Service Division
d. Economics and Sales Division

Suggestion No. 2

a. Unit Operations—Division A Fluid Flow, Distillation, Evaporation, Heat Transfer, Absorption, Extraction.
b. Unit Operations — Division B—Crushing, Grinding, Filtration, Mixing, Drying, Mechanical Separation, Crystallization.
c. Process Division — Applied Thermodynamics, Kinetics, Equilibria.
d. Commercial Division—Training, Personnel, Management Economics, Teaching, Industrial Relations.

At present this program is still in the experimental stage according to the chairman of the Program Committee.

STUDENT CHAPTERS MEETING IN BLACKSBURG

The annual convention of the Southern Regional Conference of Student Chapters of the American Institute of Chemical Engineers will be held at the Virginia Polytechnic Institute, Blacksburg, Va., April 19-22. This conference includes Virginia Polytechnic Institute, North Carolina State College, Georgia Institute of Technology, Clemson College, University of Florida, University of Tennessee, University of Alabama, Alabama Polytechnic Institute, Tulane University, Louisiana State University and Vanderbilt University.

The guest speaker will be William Knox, a representative of the Standard Oil Development Co. The tentative program is as follows:

Program

April 19—
1:00-9:00 P.M.—Registration
7:30 P.M.—Smoker—Informal mixer

April 20—
8:15 A.M.—Invocation
Welcoming addresses
9:00 A.M.—Business meeting
12:30 P.M.—Plant inspection trip (within a 50-75-mile radius of Blacksburg)
7:30 P.M.—Banquet

April 21—
8:15 A.M.—Guest speaker—Film
10:45 A.M.—Student papers
1:15 P.M.—Business meeting
9:00 P.M.—Informal dance

April 22—
8:30 A.M.—Open house and exhibits by all engineering departments

PLAN MERGER IMPERIAL CHEM. ARNOLD, HOFFMAN

Imperial Chemical Industries Ltd. of England has made an offer to acquire a controlling interest in Arnold, Hoffman & Co., Inc., chemical manufacturers of Providence, R. I.

This merger, if accepted, will enable Imperial Chemical to enter into the manufacture of dyestuffs and other synthetic chemical products in the United States as well as to provide a medium through which dyestuffs and auxiliary products manufactured by Imperial can be marketed in this country. Arnold, Hoffman & Co. Inc., has an issued capital of approximately $930,000 consisting of approximately 93,000 common shares of a par value of $10 and the price offered by Imperial is $55 per share.

The American corporation operates three plants at Charlotte (N.C.), Cincinnati (Ohio) and Dighton (Mass.) and is engaged in the manufacture of a variety of chemical products including dyestuffs, plasticisers, wetting agents.

NEWSCAST

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THERE'S GOLD IN CALIFORNIA BUT GOULD IN SENECA FALLS

PUMP PIONEERS ANNOUNCE NEW STAINLESS CENTRIFUGAL UNIT

1849 . . . the famous California Gold Rush was on! One year later Seabury S. Gould had designed and cast the world's first all metal pump at Seneca Falls, N. Y. The Gold Rush is just a memory, but Goulds Pumps, Inc., is the largest pump manufacturing plant in the world.

Their new stainless steel centrifugal pump, Fig. 3705, was created to provide economical handling of a variety of acid and alkaline liquors. Rugged in performance and economical in operation, it was designed to meet the corrosive conditions present in the chemical, process and allied industries. For economy, the fluid end, which is specified in stainless steel, is mounted on cast iron supports. This allows selection of the most suitable high alloy material for all parts in contact with the liquid, while permitting the use of less expensive materials where high corrosion or abrasion resistance is not required. From the viewpoint of maintenance, both suction and discharge connections are located in the stainless casing. Removal of the casing cover permits the pump interior to be inspected or cleaned without disturbing pipe connections.

Built to handle up to 720 gallons per minute with heads up to 200 feet, depending upon capacity, these new centrifugal pumps are ideal for the rigid requirements encountered in the process industries. To provide maximum service under the most exacting conditions, Goulds engineers have specified Cooper Alloy stainless castings for the major components in contact with corrosive media. Quality castings plus top design engineering assure long trouble-free service.

AVAILABLE UPON REQUEST technical data chart giving analyses, comparative alloy designations, properties, and applications of cast stainless, nickel and monel.

The COOPER ALLOY Foundry Co.....leading producer of Stainless Steel VALVES • FITTINGS • CASTINGS

CARBIDE NEW SYNTHETIC INSECTICIDE

Carbide and Carbon Chemicals Corp. announced last month the commercial production of allyl cinerin, one of the active principals of pyrethium. Successful production of this material points the way to U. S. independence of imported pyrethium flowers.

The announcement was made at the Boyce Thompson Institute for Industrial Research, Yonkers, N. Y., and in the photograph above the editors of the technical press are receiving from H. B. McClure, vice-president of the company, a predemonstration explanation of the new product. In the background are chambers containing flies and water roaches for comparison tests of the killing power between the new synthetic and pyrethium.

The compound was first synthesized in March, 1949, by F. B. LaForge and others, of the United States Department of Agriculture. Carbide's first attempts to synthesize the material were made about a year ago, and the first commercial production was completed in eleven months. The new material was given the generic name Allethrin by U.S.D.A. scientists.

M.I.T. SUMMER COURSE IN COLLOIDS

A three-weeks special course in the colloid chemistry of elastomers, from June 26 to July 14, a feature of the 1950 Summer Session at the Massachusetts Institute of Technology, has been announced by Prof. Walter H. Gale, director of the summer session activities.

Designed primarily for engineers and scientists from the rubber and plastics industries, the course will be given by Dr. Ernst A. Hauser, professor of colloid chemistry in the Institute's department of chemical engineering and a leading authority in the field.

The course will be held on weekday mornings. For laboratory demonstrations of manufacturing and processing methods, the equipment of the M.I.T. Rubber Laboratory will be available. Opportunities will be offered for additional discussion periods, seminars, and demonstrations in the afternoons.

Tuition for the three-week course will be $90. Academic credit will be given.

BISULFIDE PLANT FOR STAUFFER CHEM. CO.

Stauffer Chemical Co. has announced the construction of a new plant at Lowland, Tenn. The plant, which it is expected will be completed late this year, and will produce carbon bisulfide, used in the manufacture of viscose rayon and cellophane, will cost $1,000,000.

NOMINATIONS INVITED FOR PROFESSIONAL PROGRESS AWARD

The Awards Committee invites the assistance of members in selecting the first recipient of the Professional Progress Award.

The purpose of this award is to recognize distinguished achievement or distinguished contribution to the betterment of human relations and circumstances in the field of chemical engineering. The contribution may consist of—

a. A theoretical discovery or development of a new principle
b. A development of a new process or product
c. An invention or development of new equipment
d. Distinguished service to the profession

The contribution must be in the field of chemical engineering.

The Award shall consist of a certificate and $1000 in cash. The award will be made without regard to sex, citizenship, race, or residence. The recipient need not be a member of A.I.Ch.E., but must not have reached his forty-fifth birthday.

Please send properly documented nominations promptly to Dean T. K. Sherwood, Massachusetts Institute of Technology, who is Chairman of the Awards Committee.

REPORT GIVEN ON DOW EXPLOSION

Inflammable gases escaping through a blown safety disc led to the explosion which took eight lives and wrecked a portion of The Dow Chemical Co.'s latex plant during February it was disclosed in a report submitted by Mark E. Putnam, vice-president and general manager of the company, to Arnold Renner, chief of the fire marshal division of the Michigan State Police. Source of the ignition which set off the blast was still a mystery, however.

The report, which concluded nearly two weeks of study by Dow engineers and technical personnel, said welding activities, originally considered a possible ignition source, were ruled out when investigators found such work was going on only in other parts of the building separated by a 12-in. fire wall from the room where the blast occurred. The company further pointed out that all electrical apparatus and telephones in the ill-fated reactor room were an explosion-proof type.

The area was also protected by a sprinkler system and ventilating fans capable of removing 26,000 to 42,000 cu.ft. of air/min., the company said.

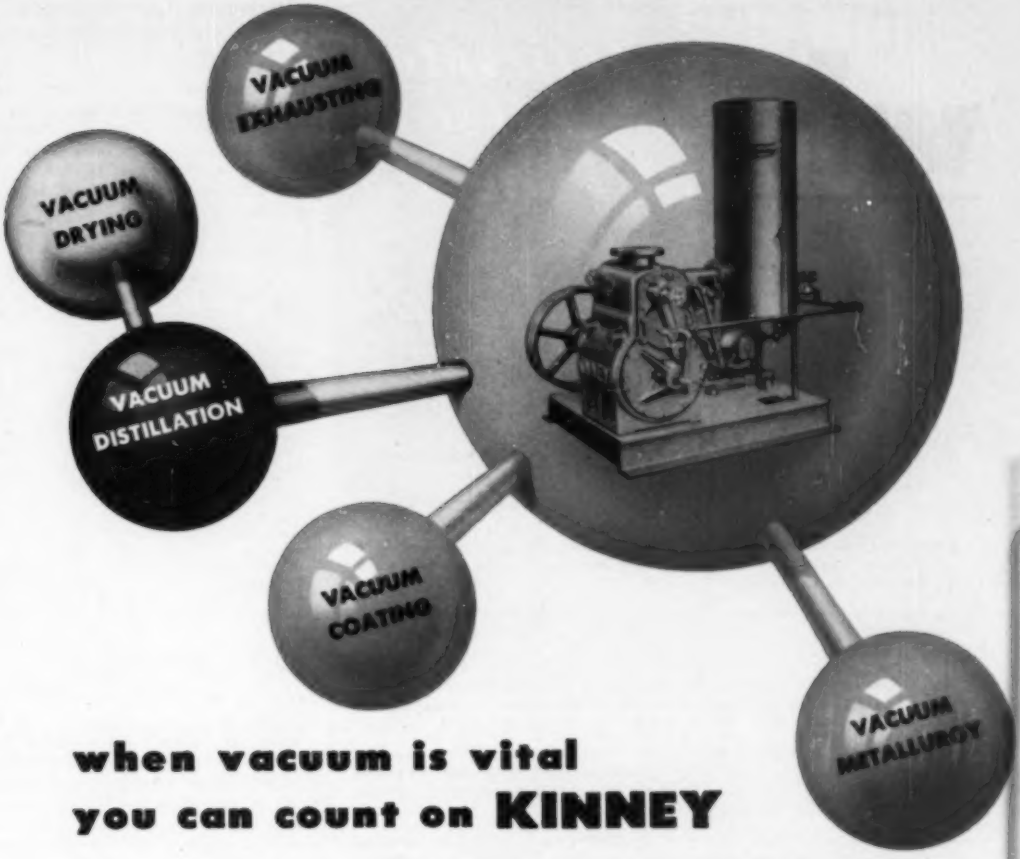
The latex is manufactured from a mixture of styrene, butadiene and water. These materials are polymerized in a steel reactor.

During the process one of the twelve reactors in the plant apparently built up abnormal pressure, the company reported, causing its safety discs to blow releasing the inflammable vapors into the room.

The company said it had engineered additional precautions into the plant which would vent the reactors directly to the outside air, but the system had been abandoned when experience proved it was not effective because the rubbery product clogged the lines.

The company added that it had for sevreal months been developing a new-type stationary reactor which is expected to afford greater safety and efficiency.

The building in which the explosion occurred was a relatively new one, having been built in 1944 to manufacture a material known as Styraloy. Styraloy, which was made from the same raw materials as the latex, was discontinued in 1946 and the equipment was converted for the production of latex. The plant had been operated almost continuously since 1944 without previous fire or explosion.



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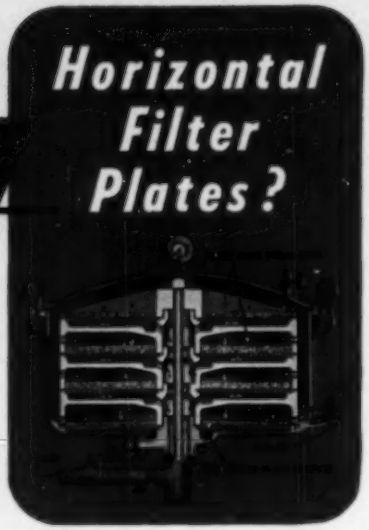

because—with horizontal plates, filter aids are permitted to flow in a natural direction, with gravity, and are deposited in an even cake of uniform thickness.

because—the filter cake rests flat on the supporting plate without tensile or distortive strain, will not crack, slip, or break under pressure, assuring even filtration.

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MIDWEST CONFERENCE ON FLUID DYNAMICS

The Midwest Conference on Fluid Dynamics will be held at the University of Illinois, Urbana, May 12 and 13. This conference is being arranged by the Fluid Dynamics Panel at the University of Illinois. Chairman of the technical program on chemical engineering is H. F. Johnstone, professor, chemical engineering department, University of Illinois.

The papers and speakers at the chemical engineering session which will take place Saturday morning, May 13, are:

Some Uses of the Mechanics of Similitude in Pilot Plant Experimentation—J. H. Rushton, Illinois Institute of Technology

Velocity Profiles in Annuli—J. G. Knudsen, University of Oregon and D. L. Katz (speaker), University of Michigan

Impact Tube Measurements in Isothermal Air Jets—J. F. Taylor, University of Illinois, and E. W. Comings (speaker), University of Illinois

Application of the Reichard Equation—T. Baron, University of Illinois

Surface Velocities of Liquid Films in Streamline Flow Region—M. L. Jackson, (speaker), University of Colorado, and R. T. Johnson and N. H. Ceaglske, University of Minnesota

A.S.E.E. MEETING IN JUNE IN SEATTLE

The 1950 annual meeting of the American Society for Engineering Education will be held on the campus of the University of Washington at Seattle, Wash., from June 19-23. Engineers engaged in teaching and industry will discuss problems of curricula, report writing, mathematics for chemical engineers, accrediting, and financing before the division of chemical engineering. Among the speakers will be L. M. K. Boelter, Mott Souders, Jr., G. G. Brown, and Lloyd Berg, all members of A.I.Ch.E. The division dinner will hear Prof. M. P. O'Brien, chairman, department of engineering at Berkeley, on "The Nature of Engineering."

CHEMICAL EXPOSITION OF A.C.S. IN CHICAGO

"A Half Century of Chemical Progress" will be the theme of the Sixth National Chemical Exposition sponsored by the Chicago section of American Chemical Society which will be held in the Chicago Coliseum, Sept. 5-9, 1950. Dr. Marvin C. Rogers, director of research, R. R. Donnelley & Sons, is chairman of the exposition committee.

Many special features and special exhibits are planned. An educational feature will include an exhibit of chemical textbooks, biographies and scientific contributions of outstanding chemists.

AMERICAN REPUBLICS CORPORATION

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American Republics Corporation depends on ALCOA Activated* Alumina to dry residue gas at their Silsbee, Texas, gasoline plant.

Each of the two dehydrating towers, illustrated, is charged with 16,000 lbs. of ALCOA Activated Alumina. Gas, entering the towers at approximately 100° F. and 900 psig, is dried to dew points not exceeding *minus* 10° F. Approximately 15,000,000 standard cubic feet of gas passes through the towers daily. Reactivation is accomplished with natural gas heated to 375° F.

ALCOA Activated Alumina was chosen for this installation because it is *dependable* and *economical*. It can be reactivated an almost unlimited number of times, without appreciable effect on its moisture adsorption efficiency.

ALCOA Activated Alumina will readily and repeatedly adsorb moisture from vapors and gases to dew points below *minus* 100° F. without changing its form or properties. It does not soften, swell, or disintegrate even when immersed in water. Furthermore ALCOA Activated Alumina is chemically inert to most gases and liquids, and is non-toxic.

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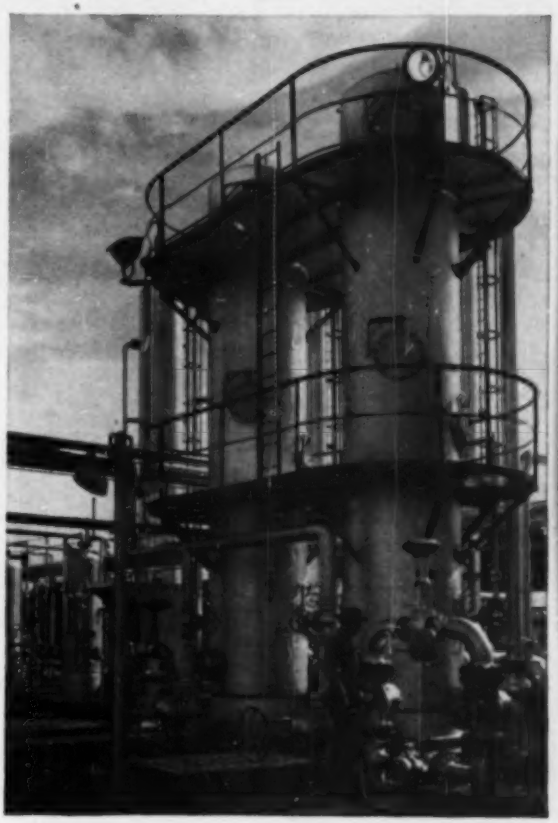

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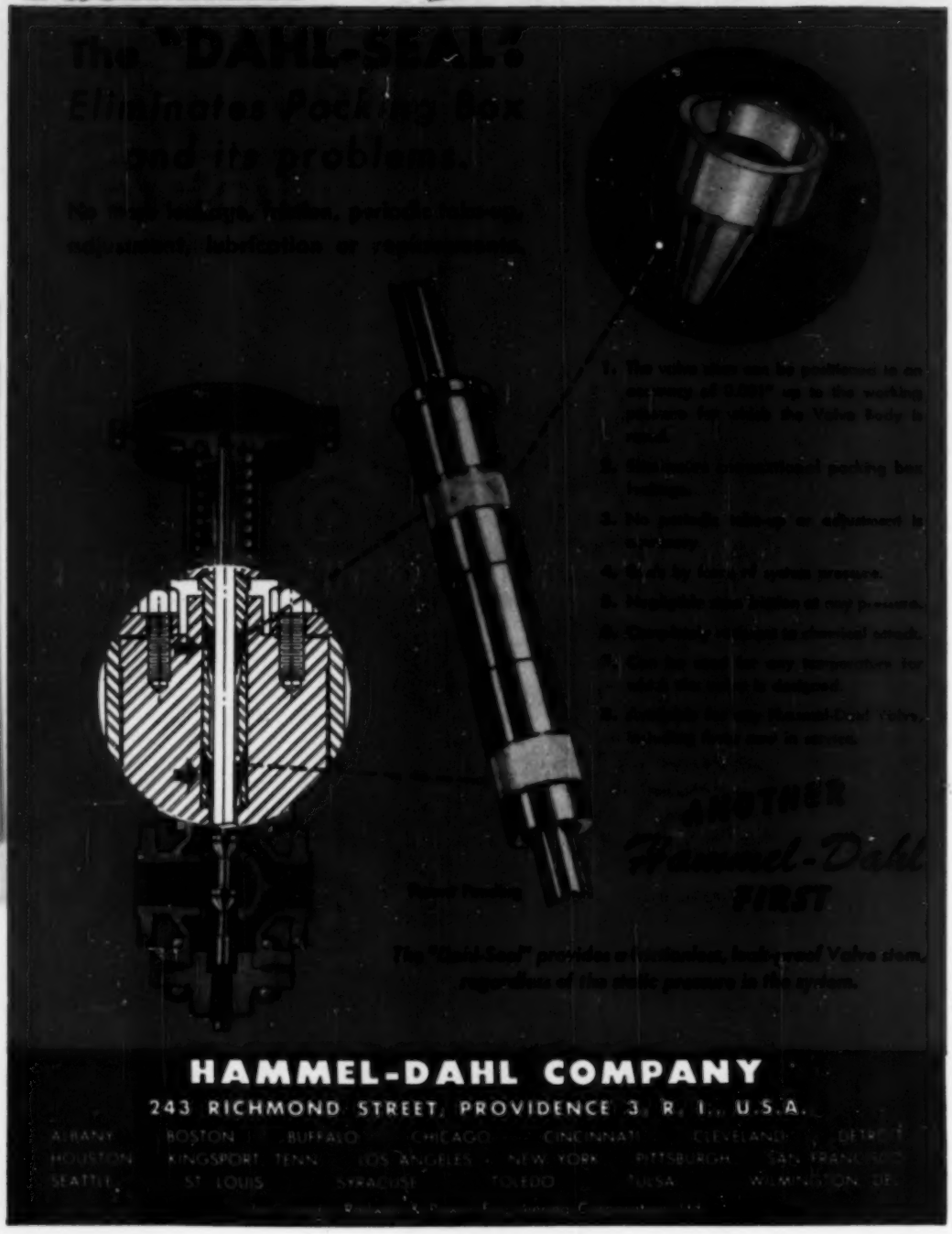

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BULLETINS

1 • *EVAPORATORS.* A bulletin from General American Transportation Corp., process equipment division, on types of evaporators. Contains a description of the flat plate heating surface evaporator with a self-cleaning provision. This is a recent Scandinavian development and company is licensee in the United States. Other pages contain a discussion of evaporation as a unit operation, the design trend in evaporators, descriptions of the various types—the integral self-supporting evaporator, the long-tube film-type, vertical recirculators, etc.

2 • *CLEANING COMPRESSED AIR.* From the Logan Engineering Co., a bulletin on the Aridifier, a centrifugal separator for removing moisture, dirt, oil, and fine scale from compressed air lines. The compressed air supplies the motive power for four multiblade rotors or impellers. The moisture and air are impinged upon the blades, and the impurities are thrown by centrifugal force, to the outer edges. Beside a description of the apparatus and its operation, installation pictures, tables on compressed air discharge, diameters and volumes of pipes, and a table on quantity of air used by various pneumatic machines round out the publication.

3 • *COOLING TOWER.* A brief description of the new Aquatower line of water-cooling towers made by The Marley Co. The towers are a standard packaged line, completely assembled. Capacities range from 3 to 50 tons. Specifications and dimensions of the various towers are given.

5 • *SEWAGE GRIT REMOVAL.* A technical supplement from the American Well Works, Inc., describes the Camp Grit Channel and Regulator developed for removal of grit in the sewage treatment field. One feature of the channel is its rectangular cross section which is designed so that velocity of flow is constant regardless of quantity. Through the regulator on the grit channel, operators can maintain the best velocity for grit removal. Information on grit chamber design, including methods of calculating the cross section of the chamber, the length of the chamber, a design for low head loss, and a design for normal head loss is given.

6 • *THE GLASS LINING.* A house magazine of the Pfaudler Co. for the dairy, food, beverage, and chemical industries. Features glass-lined equipment and contains various processing articles. This issue contains a feature by W. L. Faith, director of engineering, Corn Products Refining Co., on the use of tanks and kettles for general pilot plant work.

7 • *CENTRIFUGALS.* A booklet on centrifugals for the process industries which contains sections on how centrifugals are employed, descriptions of baskets, the suspended centrifugals, and center-slung centrifugals of the Tolhurst Co. A discussion on factors influencing dryness and capacity, plus an alignment chart on the determination of centrifugal force, round out this 16-page bulletin.

8 • *PLASTIC FILTER FRAMES.* St. Regis Sales Corp. is offering filter frames made of Panelyte, a phenolic resin laminate. The plates are designed to give greater chemical resistance than cast iron, as well as greatly decreased weight. The plates are solid pieces, with no tie rods. A one-page descriptive sheet showing two types of filter plates, plus details of the drainage elements.

9 • *MULTI-POSITION MOTOR.* A line of gear head electric motors which can be mounted in any position, horizontal, inverted, side wall, or vertical, without loss of lubrication, is a newly announced feature of Sterling Electric Motors, Inc. The gear head motors will give the correct speed for any application; has dip-and-splash lubrication.

10 • *THERMOWELLS.* For Thermowells of every size, shape, and description, Trinity Equipment Corp. has a new catalog of 44 pages. Completely illustrated and documented with data and illustrations of each individual Thermowell type, the booklet also has tables on the chemical properties of various metals, another table which gives the physical properties and mechanical properties of these same metals, plus a material selection table which gives the recommended metal for a Thermowell depending on temperature conditions of various corrosive substances. In addition, Trinity makes and shows crude assay stills, Parr bomb chambers, propane flash pots, grease viscometers, strainers, reflux heads, etc.

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11 • PRESSURE VESSEL ACCESSORIES. Complete engineering data and specification details on pressure vessel accessories, are in a new 64-page catalog of the Lenape Hydraulic Pressing & Forging Co. It describes necks, manways, nozzles, tank sumps, various flanges, etc. The handbook section contains various conversion factors, dimensions of bolts and nuts, pipe dimensions, standard flange facings, pressure-temperature ratings, etc.

12 • DOWTHERM VAPORIZER. The McKee Dowtherm vaporizers of the Eclipse Fuel Engineering Co., are described in a new engineering pamphlet. Shows the various types of Dowtherm vaporizers made, plus data on heat transfer, comparison of latent heat of Dowtherm and steam, sizes and specifications of vaporizers, plus physical properties of Dowtherm A.

14 • EXPLOSION-PROOF SUMP PUMP. A totally enclosed, automatically electric sump pump, which has underwriters' approval for Class I, Group D, and Class II, Groups E, F and G hazardous locations, is described in a flyer of the Penberthy Injector Co. Gives details of the construction, as well as prices, capacity, depth of sump, height of pump, etc.

15 • WATER SOFTENERS. A comprehensive bulletin on recent developments in hot-process water softeners is new with the Graver Tank & Manufacturing Co. Beginning with a discussion of the operating problems requiring boiler feed-water treatment, the booklet explains the twelve principal methods of feed-water treatment and then goes into detail on the hot-process treatment. Treatment and advantages are described. Pages of flow diagrams explain different systems, and the last of this 36-page book is given over to other equipment and flow sheets of typical installations.

16 • MAGNETIC PROTECTION. Sprout, Waldron & Co., Inc., are now making permanent Alnico magnets for the removal of tramp iron. The units can be installed in either wood or metal feed spouts and can be furnished in any width. A bulletin available shows how the magnet can be installed on disc refiners, hammer mills, pellet mills, etc. Installation data are contained in a separate data bulletin.

17 • MERCURY MANOMETER FLOW METER. Fischer & Porter Co. announce a new bulletin describing mercury manometer flow meters which eliminate pressure-tight bearings and stuffing boxes. The new flow meters are available in several models. Can be furnished with 35-in. to 400-in. water column equivalent range tubes. Withstand 1500 lb./sq. in. pressure. Bulletin describes the instrument, its magnetic clutch, electric impedance bridge transmitter, gives engineering specification data, and, briefly, other F. & P. instruments.

18 • FIRE EXTINGUISHER INSPECTION CHART. For those safety engineers who need to check on fire extinguishers, the Ansul Chemical Co. has a periodic inspection record for maintenance of fire extinguishers. Space for 26 inspections of 30-odd extinguishers.

19 • STEAM TURBINE. De Laval, in a 4-page bulletin, describes a new, single-stage turbine for high pressure, high temperature service. This particular model uses an initial steam pressure of 1450 lb. and a back pressure of 300 lbs. From 600 to 2000 hp.

20 • GLASS-BLOWING EQUIPMENT. Scientific Glass Apparatus Co., Inc., in a 50-page bulletin, pictures all equipment necessary for glass blowers. In addition to the equipment itself, there is a whole section devoted to the different types of stopcocks.

21 • THERMAL INSULATION. A booklet illustrated with numerous application photographs, shows the Fiberglas thermal insulation of the Owens-Corning Fiberglas Corp. Various insulations are described along with properties and characteristics. Data on thermal conductivity, sound absorption, weight, physical characteristics, etc. Applications are shown for many industrial installations.

22 • CORROSION DATA. Haynes Stellite division of the Union Carbide & Carbon Corp., tells the complete corrosion-resistant story of four Hastelloy alloys in a new edition of the 40-page book, "Corrosion Resistant Alloys." Chemical composition is given, and then pages of corrosive-media data on hydrochloric, phosphoric acid, sulfuric acid, organic acids, nitric, etc. Gives penetration results, and contrasts the physical and mechanical properties of Hastelloy alloys. Shows available forms, fabrication procedures, etc.

24 • CENTRIFUGAL RESEARCH. Bird Machine Co. has a new pamphlet which describes its research and

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development center. The equipment used in materials-handling research is shown in excellent pictures. Describes centrifugal separation, tests and equipment, filtration, etc. Tells stories of how waste materials have been salvaged by research done at the Center, and ends up with a picture description of all the equipment made by the Bird Machine Co. Of interest to coal, chemical, paper, pulp, and processing industries.

25 • *PNEUMATIC TRANSMISSION.* A primer of Republic Flow Meters on pneumatic transmission devices. The book begins with principles of measurement and goes step by step through construction features, operating principles, design and performance features, materials of construction, etc. Well illustrated. Principles are shown by line drawings.

26 • *ALLOY CHAINS.* For handling sticky, abrasive materials, Beaumont Birch Co. is making new Beaucalloy chains, traction wheels and buckets. Bulletin shows construction of links, buckets, etc., data on alloy, plus features of construction which make for long service. Bucket has a dovetail lock which eliminates conventional bolting, gives smooth inside face free of bolt projection.

EQUIPMENT

27 • *TOTE SYSTEM.* For those interested in bulk handling of materials, a general news feature of the Tote System, Inc., will contain for them a complete explanation of the technique worked out by this company. The system is built around the Tote bin, a rectangular container which will carry a load of more than two tons.

28 • *VISCOMAT.* A joint announcement of the Brookfield Engineering Labs., Inc., and Brown Instruments division of Minneapolis-Honeywell Regulator Co. tells of a new indicating and recording instrument called Viscomat. The instrument is capable of indicating and recording viscosity changes as small as ¼ of 1 per cent of scale, from a minimum of 20 cp. to a maximum of 100,000 cp. Combined with a recorder, the new instrument can be used as an automatic controller with built-in audible or visual alarms. The viscosity measuring spindle may be immersed in the fluid being measured, without samples being taken.

29 • *LEAD BRICKS.* For use in protecting personnel from radiation in neucleonic experimentation, the Nuclear Instrument & Chemical Corp. has developed interlocking lead bricks which eliminate the low density joint space between ordinary rectangular lead bricks. Interlocking sections are so designed that a complete dense wall may be obtained by fitting the bricks together. Four different shapes available.

30 • *LABORATORY MICROFEEDER.* A microfeeder designed to inject in an uninterrupted flow through a capillary tube and injection needle, which has a feeding rate as low as 1 cc./hr., is a new development of % Proportioners, Inc. %. The company presents this development as a catalyst activity testing charge pump. Feed is delivered without pulsation of flow, and is accurate within ± ¼ of 1%. A change of gears, readily accessible, gives a choice of different space velocities.

31 • *BLADELESS PUMP.* A new type pumping unit for handling trash, sewage, and large particle materials such as paper and textiles, has been developed by Fairbanks, Morse & Co. The pump impeller is bladeless and the fluid passes through the impeller to a single-rotating channel. The curved channel starts at a small radius at the axis of rotation, and fans out in a helical path. The centrifugal action throws the fluid against the side of the bent channel and since this slants forward, the fluid is driven along. Bulletin describing details of construction and use, available.

32 • *PROCESS PUMP.* A De Laval general service pump, for use in process industries handling liquids that are viscous, corrosive, or carrying suspended solids, and which can be furnished with open or closed impellers, is new with the company. A feature of the pump is that the entire rotor can be adjusted axially by means of an external adjusting screw. This is to compensate for wear of the impeller face. The pump can be changed from open to closed impeller or vice versa, easily.

33 • *PORTABLE AGITATOR.* A heavy-duty liquid agitator which can be moved from one tank to another, for batch mixing and blending, is newly developed by Mixing Equipment Co., Inc. The new agitator is a turbine type and is mounted on casters for transportation between tanks. Correct mixing speed is determined by a variable speed con-

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Company _____

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trol, and the impeller shaft and the impeller are raised and lowered hydraulically. Unit has its own baffles and is supplied in capacities up to 4½ hp. in any metal, for the individual processing.

34 • ***LEVEL INDICATORS.*** Direct reading of level indicators, with illuminated dials, are new with the Panalarm Products, Inc. Changes in levels from any source from any remote point are reproduced on a graduated, illuminated dial. Instrument operates on any 3 to 15 lb. pneumatic transmitter, or direct from the valve-loading pressures. Available in single units or in multiple units, they may also be equipped with high- and low-level alarm switches.

35 • ***PRESSURE RELIEF VALVE.*** Cartridge-type hydraulic relief valve available with pressure settings ranging from 100 to 5000 lb./sq.in. is now being made by Pantex Manufacturing Corp. Company states valve opens and closes within a 7% differential. Data sheets, descriptive literature, etc., available.

36 • ***SELF-CLEANING HEAT EXCHANGERS.*** Davis Engineering Corp. has a new heat exchanger that automatically cleans itself at predetermined intervals. A bulletin is available which explains the cleaning mechanism. Transverse baffles are connected by the rods to a drive mechanism. By moving the baffles along the heater tubes the tubes are scraped down.

37 • ***GLASS PIPE GASKETS.*** Industrial snap-on gaskets that are self-centering and noncorroding, are being made by United States Gasket Co. for conical end glass pipe. The gaskets are made of Teflon and are resistant to corrosive chemicals.

38 • ***CORROSION RESISTANT HOMOGENIZER.*** Colloid Equipment Co., Inc., introduces a stainless steel hand homogenizer which can handle acids and caustics. For use in laboratory and pilot plant experiments, the homogenizer incorporates a complete new design. All fluids come in contact with corrision resistant stainless steel. No gaskets or washers. Is adjustable to various pressures. Lever operated. 9-ounce capacity, weight 8 lb., cost $19.95.

39 • ***VALVES.*** A complete new line of Hancock bronze valves having 500 Brinell stainless steel seats and discs and a diaphragm construction of improved strength is a new product of Manning, Maxwell & Moore, Inc. The new bronze valves are being manufactured in sizes of ¼ in.-2 in. and are available in globe and angle types. Designed for pressures up to 150 lb./sq. in. saturated steam or with non-shock cold water, oil, or gas service, up to 300 lb./sq. in.

40 • ***FOR RUBBER-LINED PIPE.*** For cutting, facing, grooving and counterboring flexible, hard rubber-lined pipe, Gates Engineering Co. has a new Gaco pipe tool which will fit 1½ to 4 in. diameter pipe. The tool was developed to eliminate costly methods of pre-engineering and prefabricating. It is designed especially for adaptation with the company's special pipe joints.

41 • ***PRESSURE TRANSMITTER.*** A new force-balance-type pressure transmitter which makes it possible to measure and transmit, up to 1000 ft., a small pressure change with an accuracy of ½% of the range span, is the claim of Taylor Instrument Co. for its new Transaire pressure transmitter. Narrow range spans are available over 35 to 450 lb./sq. in. abs., with a sensitivity of 0.1%. Other features such as stainless steel construction, linear output of transmitter, varied operating ranges, etc., are explained in company bulletins.

42 • ***CHEMPUTER.*** A circular slide rule for calculating any problem of simple proportion is now on the market by the Coleman Instruments, Inc. It establishes any linear calibration, retains such calibrations, signals potential errors in standard data, etc.

43 • ***SPRAY DECK COOLER.*** For food freezing, storage, candy, ice cream, and other refrigerating processes, Niagara Blower Co. has a new spray fan cooler for installation in refrigerated rooms where high capacity is required but ceiling height restricted. Air is washed, chilled, and discharged, and five unit sizes are offered with capacities ranging from 1680 to 11,000 cu. ft./min. of chilled air.

CHEMICALS

50 • ***PLASTICIZER.*** Dioctyl adipate, an odorless plasticizer for vinyls and other synthetic resins was announced in production by B. F. Goodrich Chemical Co. Of low acid content, the new compound designated GP 233 was specifically designed to improve low temperature properties of vinyl. Company states that tests have shown vinyl compounds so plasticized will withstand temperatures as low as −70° F. without becoming brittle.

51 • ***SURFACE ACTIVE AGENTS.*** Monsanto Chemical Co. introduced two nonionic surface active agents for industrial use. Both are polyoxyethylene thioethers and compatible with anionic- and cationic-type detergents and are effective in hard water and in the presence of metallic salts. A bulletin which has descriptive data, and chemical and physical properties such as wetting speed, interfacial tension, compatibility, etc., and suggested uses for the two new surface active agents is available from the company.

52 • ***ALUMINUM PAINT.*** The use of aluminum paint in industry is described and illustrated in a comprehensive 32-page booklet distributed by the Aluminum Co. of America. Applications of aluminum paint are given in some detail; the company points out the advantages of the paint and shows how it can be used either as a primer or finishing coat.

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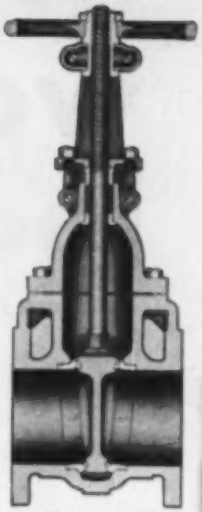

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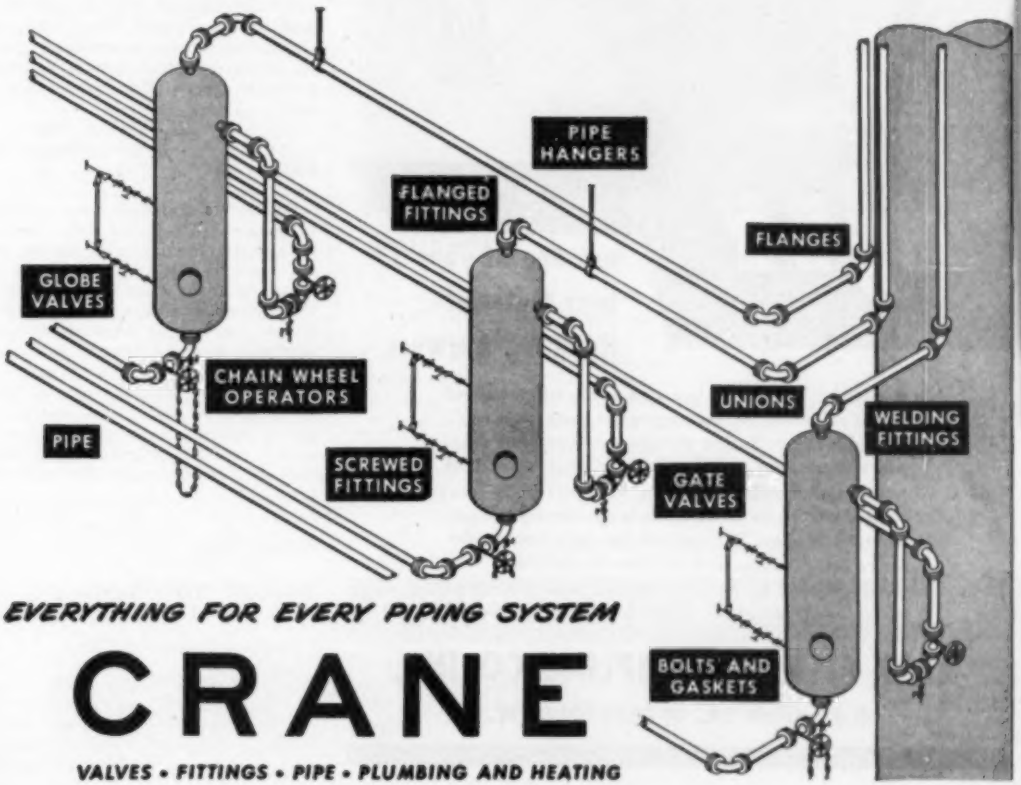

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LETTER TO THE EDITOR

Something on "Something for Nothing"

Sir:

In the February issue . . . C. G. Kirkbride was author of an Opinion and Comment, "Something for Nothing." The last paragraph specially attracted my attention. It is obvious that some members of the Institute at the higher levels recognize the lack of a complete cooperation of the membership of the chemical engineering profession with the A.I.Ch.E.

An organization is as effective as it is democratic. Wisdom should flow up from the lower ranks of membership as well as passed down from the higher up. The Associate and Junior members are denied the right to participate in the affairs of the Institute and to vote. To me this is taxation without representation. Those of us who have retained our membership for a number of years and continue to support the Institute, it is because of our devotion to the chemical engineering profession, but in no wise is it an approval of the manner in which the Institute is organized and administered. If we are lukewarm towards the Institute, it is as much the fault of the Institute as of ours. I should, therefore, like to see every member having the right to vote and actively participate in the affairs of the Institute. . . .

M. G. Larian,
East Lansing, Mich.

Feb. 22, 1950.

Author's Comment: I am inclined to agree with Dr. Larian that it would be desirable for a greater number of the Institute members to take direct part in its work. When the Membership Policy Committee considered the problem of membership requirements and privileges, there was a strong feeling by at least two members of the Committee that both Junior and Associate members should have the right to vote as well as Active members. I personally feel that sooner or later serious consideration shall have to be given to this question.

C. G. Kirkbride,
Marcus Hook, Pa.

March 8, 1950

REPORT NO. 4 TENN. VALLEY AVAILABLE

Chemical Engineering Report No. 4, "Agglomeration of Phosphate Fines for Furnace Use" is another in the series of reports covering major projects of the Tennessee Valley Authority. A few copies are available for free distribution to persons having a special interest in

the developments, and may be obtained by writing to: Tennessee Valley Authority, Division of Chemical Engineering, Wilson Dam, Ala. Report No. 4, like the other reports, also may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. This report is compiled by E. L. Stout.

WATER POLICY BY E. J. C.

Because of the broad knowledge and experience of the members of the engineering profession in the general matter of water resources development and utilization, the Engineers Joint Council at its meeting Jan. 20, 1950, approved a program for outlining the profession's conception of the elements of a sound national policy and for presentation of specific recommendations to the temporary Water Resources Policy Commission which was created Jan. 3 by an executive order of the President of the United States. This temporary Presidential Commission included in its procedure an opportunity for all persons and organiations concerned with water resources, to bring to its attention their conception of the elements of a sound water policy for the nation.

EJC has had this subject under study for the past two years. It is convinced that adequate conservation and development of our national water resources are unattainable under present uncoordinated and frequently opposing policies and that present practice is detrimental to the nation's economic progress. These conclusions were brought out January, 1949, in a report to Council's Water Policy Committee. At its November, 1949, meeting, Council instructed its Water Policy Panel to take whatever steps might be indicated to create a commission which would review present water resources policies and make recommendations to the Congress for revision and restatement. The Panel thereafter conferred with other organizations having a similar interest, and was considering presentation to Congress at the time the temporary Commission was created by the President.

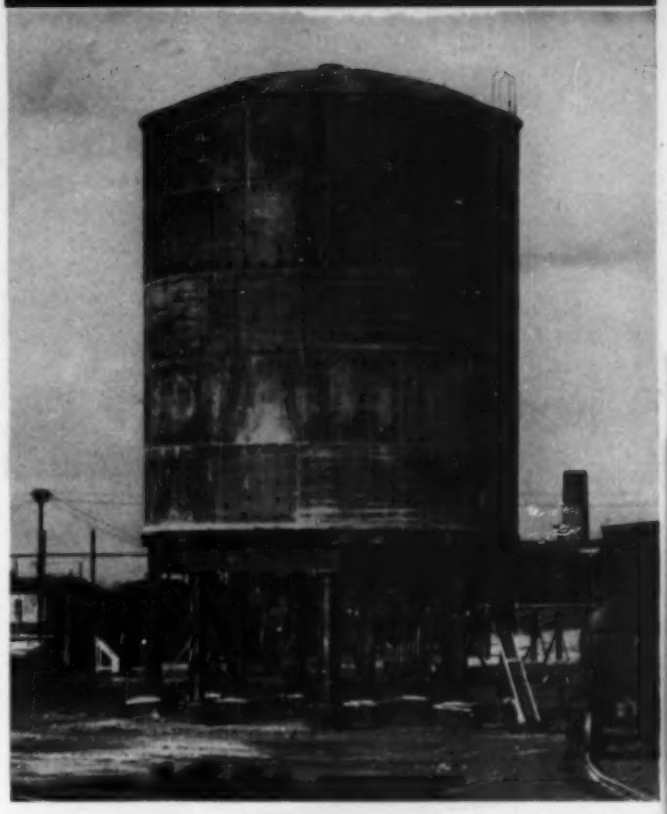
Under Council's program of Jan. 20 task committees are now being set up.

Members of the EJC Water Policy Panel who will have the administrative responsibility for the project are:

R. D. Hoak, A.I.Ch.E.
E. L. Clark, A.I.M.E.
C. W. Mayott, A.I.E.E.
W. F. Uhl, A.S.M.E.
W. W. Horner, A.S.C.E., *Chairman*

Since the President has directed his temporary commission to complete its work by Dec. 1, 1950, recommendations from the engineering profession should be transmitted by July 1.

HORTON Steel Storage Tank



For 77.7 Per Cent Sulphuric Acid

Here's how a chemical plant in northern Illinois uses a Horton * steel tank of welded construction in its operation. 77.7 per cent sulphuric acid manufactured at the plant is pumped into this 1,500-ton tank at the rate of 150 tons per day. The tank, which is 31½ feet in diameter by 35 feet high, is mounted on a grillage 15 feet above the ground and the acid flows from it by gravity into tank cars or tank trucks for delivery to the steel mills.

The self-supporting umbrella roof on the tank shown above is a popular type because it leaves the inside of the tank entirely clear of obstructions. When you need welded steel storage tanks like this or of any other design, get an estimate from our nearest office.

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Birmingham 1	1540 North Fiftieth St.	New York 6	3323—165 Broadway Bldg.
Boston 10	1035—201 Devonshire St.	Philadelphia 3	1640—1700 Walnut Street Bldg.
Chicago 4	2138 McCormick Bldg.	Salt Lake City 4	860 West 17th South St.
Cleveland 15	2332 Guildhall Bldg.	San Francisco 11	1236—22 Battery Street Bldg.
Detroit 26	1546 Lafayette Bldg.	Seattle 1	1360 Henry Bldg.
Houston 2	2154 National Standard Bldg.	Tulsa 3	1643 Hunt Bldg.

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This is a treatment we developed in our own laboratory and foundry to meet special conditions for certain furnace operations. Normal high alloy castings would withstand the heat all right but abrasion, erosion and pick up were something else again. The "Duralized" Rolls solved the problem.

While you may not need a high alloy casting calling for the Duralizing treatment, you may have a high alloy casting problem. We'll be glad to study it with you and recommend the alloy and type of casting best for your requirements.

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A.S.E.E. STUDY SHOWS ENGINEERS NEEDED

Unless the percentage of high school graduates entering engineering colleges is increased, there is a strong probability that instead of a large surplus of engineering graduates, which has been prophesied rather widely, there will soon be fewer engineering graduates available than are needed annually by our national economy. This is the conclusion drawn by a subcommittee of the Manpower Committee of the American Society for Engineering Education from a study of trends in secondary school and engineering college enrollments, and of the statistics on 1949 engineering enrollments and graduations recently assembled jointly by the Society and the U. S. Office of Education, which are to be published soon by both organizations.

"The disturbances of the early war years caused a serious shortage of engineers, which was widely publicized," the report said. "This publicity, coupled with war experiences of individuals, was undoubtedly a strong factor leading an unprecedented number of students, veterans and nonveterans, to enter engineering colleges in 1946. Freshmen in that fall numbered about 93,000 in all United States engineering colleges listed by the U. S. Office of Education, and constituted 8.6 per cent of high school graduations of the preceding June, compared to a prewar average of about 3.2 per cent. Other classes were also large, and predictions of an oversupply of engineers became numerous.

"Freshmen engineering enrollments have declined steadily since 1946, until in 1949 they constituted only 3.0 per cent of the June high school graduates, and made up a class of 42,000, no larger than it would have been had prewar trends continued undisturbed through the war years.

How Many Engineers Are in Prospect?

"Of the 93,000 freshmen engineering students of 1946, 55,000 are now seniors. If the 'survival ratio' of last year holds good this year, there will be about 51,000 engineering graduates in 1950. Assuming a gradual return over the next three years to prewar 'survival ratios' indicates about 35,000 engineering graduates in 1951, about 25,000 in 1952, and about 19,000 in 1953. Prewar ratios applied to U. S. Office of Education estimates of future high school seniors indicate a steady decline in engineering graduates beyond 1953 to a low point of about 15,000 in 1957, followed by a slow rise to about 21,000 in 1965.

How Many Engineers Are Needed?

"A . . . report of Bureau of Labor Statistics estimates an average annual need for engineering graduates of between 17,000 and 18,000 per year during the early part of the 1950-60 decade, rising to an average annual demand of about 22,000 per year by 1960. This estimate is based on the number of engineers needed for actual engineering jobs, including anticipated expansion and the needs for replacing engineers who die, retire, or leave the profession. However, a recent survey by the Engineers' Joint Council of the actual placement results in engineering colleges indicates that about 35,000 graduates of last year's class have actually been placed in jobs which utilize their engineering training, a figure almost twice as

large as the Bureau of Labor Statistics estimate. About 6,000 entered graduate schools, and the employment status of about 3,000 is unknown.

"Reports of the Manpower Committee for the past several years have emphasized the fact that engineering is still a growing and expanding profession; that not only the total number of engineers, but also the ratio of engineers to total employment, have been steadily rising ever since employment statistics have been assembled. Many factors operate toward a continuation of this increase in the ratio of engineers to total employment. Among these are: the continually increasing need for engineering and research in industry and Government, the tendency for engineers to develop new processes and services which create needs for new kinds of engineers and technicians, and the growing tendency of employers to recruit men with engineering training for jobs which have not in the past been considered engineering jobs, but for which an engineering background is becoming more and more useful.

"The small excess of engineering graduates over engineering employment this year and next year will undoubtedly be absorbed in nonengineering work, especially administrative, application, and technical sales positions, for which engineering training has been found to be an excellent preparation.

"The indicated number of engineering graduates in 1952 will be much smaller than the number actually placed in 1949, and by 1953 engineering graduates are expected to be fewer in number than the Bureau of Labor Statistics estimates will be needed for actual engineering jobs. From 1954 to 1965 or later there will develop a serious shortage of engineers, unless the ratio of freshman engineers to high school graduates is increased.

"This could be caused either by an increase in the percentage of college freshmen who enroll in engineering, or by an increase in the ratio of high school graduates who go to college, with little or no change in the percentage of college freshmen enrolled in engineering. In view of the increasing opportunities for college graduates in all fields, and of the small percentage of well qualified high school graduates who now enter college, the latter seems the more promising."

INDUS. HYGIENE COURSE AT UNIV. MICHIGAN

An Inservice Training Course in Industrial Hygiene and Human Relations for Safety Personnel is being offered by the University of Michigan School of Public Health, June 19-21, 1950, at the School of Public Health Building, 109 South Observatory Street, Ann Arbor.

The course is designed especially for the benefit of safety personnel, i.e., anyone responsible for safety. Applications for enrollment should be submitted in writing by letter addressed to H. E. Miller, school of public health. The fee is $5.00. The broad subjects covered in the course content are Sanitation; Plant Layout; Plant Skin Hazards; Industrial Health Problems, Part I, including plating pickling, spraying, sand blasting, etc., and Industrial Health Problems, Part II, including poisonous metals, and dusts.

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MARGINAL NOTES

News of Books of Interest to Chemical Engineers

Saga of a Metal

The Story of Magnesium. W. H. Gross. American Society for Metals, Cleveland, Ohio. (1949) xi, 258 pp. $2.00.

Reviewed by Lincoln T. Work, Powdered Material Research Laboratories, Cambridge 39, Mass.

THIS book in the series for self-education was written by a metallurgical expert from the technical service department of Dow Chemical Co. The text has been reader-tested at the high school level. It tells the story of a metal that has, within recent years, increased in production approximately one hundred fold, with correspondingly large reductions in price. It is now lower in price on a price-volume basis for ingot metal than all other metals except iron.

The book presents a discussion of the economic status of various standard alloys and properties of magnesium as introductory material. Then follows history, production, and various steps of alloying, melting, refining, casting, fabrication, machining, joining and surface finishing. The book closes with a chapter on physical metallurgy and another on uses. It is printed on good paper and is profusely illustrated with schematic diagrams, flow sheets and photographs.

For one interested in a concentrated story of this expanding field which is, at the same time, simply presented to the reader, this book would be most informative. It is good self-educational material for a general knowledge of the field.

For Tyro and Professional

Chemical Engineering Plant Design. Third Edition. Frank C. Vilbrandt. McGraw-Hill Co., Inc., 330 West 42nd Street, New York, N. Y. x + 608 pp. $6.00.

Reviewed by David E. Pierce, General Aniline & Film Corp., New York, N. Y.

GROWN to impressive proportions, the present edition of Vilbrandt's book still carries on the author's original intention of serving as a tool for "advanced students of chemical engineering, recent graduates of such courses, and seasoned professional chemical engineers." In addition, the author suggests it as a guide to executives in the chemical engineering industries "for their appreciation of the application of chemical engineering principles to plant design." It is unlikely that any book could take in that much territory with entire success. This book presents a tremendous amount of material, some of it of interest to each type of reader mentioned but mingled in such a way as to reduce its effectiveness in serving each class.

The first quarter of the book deals with Foundations, Drainage, Piping Installations, Pumps and Pumping, and The Building. Then comes a chapter on Power and Power Transmission. This is followed by chapters on Development of The Design Project, Flow Diagrams and Selection of Process Equipment. Two more chapters cover Plant Layout and Elevation and Locating The Chemical Plant. The final chapter presents Preconstruction Cost Estimating. In appendices there are General Tables, Elementary Problems and Student Process Design Projects Assignments. A 22-page index completes the 608 pages.

There is no other book covering the field of chemical engineering plant design. Therefore, this one, in spite of such faults as the inclusion of much material of doubtful value, reproduction of many charts and tables available in standard handbooks, and lack of critical appraisal of contradictory data still meets a real need. For the chemical engineering student, it supplies a vocabulary of terms from related fields of mechanical and civil engineering as well as a somewhat verbose over-all survey of what must be done in translating a process from test tube to plant operation. For the experienced engineer, there is value in the extremely complete bibliography accompanying each chapter and in references to literature so recent as to be found only in current journals.

Acetylene Yesterday and Today

Acetylene and Carbon Monoxide Chemistry. John W. Copenhaver and Maurice H. Bigelow. Reinhold Publishing Corp., New York, N. Y. (1949) 357 pp. $10.00.

Reviewed by F. M. Meigs, Director, Development Department, General Aniline & Film Corp., New York, N. Y.

SINCE acetylene under pressure as a chemical raw material is undoubtedly on the way to becoming an important factor in chemical industry, every chemical engineer should be acquainted not only with the new methods used to handle this gas safely, but also with the new reactions which are potentially realizable from it commercially. Consequently this book will be welcomed by the chemical engineer as well as by the chemist, both of whom have looked forward for a long time to owning a comprehensive treatise on the new German advances in acetylene chemistry developed by Dr. J. W. Reppe and his many co-workers in Germany. The engineer, of course, will be particularly drawn to the safe handling of acetylene under elevated pressures, while the chemist will lay more emphasis on the novel reactions ensuing from such procedures. Both of these fields are well covered in this treatise. It is, of course, recognized that treatment of safety in a book of this type cannot be comprehensive. The engineer must go to all possible original sources and then proceed with every caution.

To try to cover the German developments in acetylene chemistry in 357 pages is indeed a difficult task, but one which the writer feels is well handled by the authors. In describing so enormous an amount of work, it is naturally impossible to include much engineering detail, but good descriptions of many processes are given. For additional engineering details, the references given in the book to *PB* reports pretty well cover the available information. The text is well written and readable. There are not too many typographical errors, and these should be easily recognized by the chemical engineer.

The chief criticism which the writer feels he should make is that the index is entirely inadequate. For example, hexamethylene diamine, a nylon intermediate closely related to butynediol or propargyl alcohol, is not even listed in the index—barely three pages long. It is also regrettable that the assignment of patent numbers to the German patent applications cited as references could not have been made more complete. Nevertheless Drs. Copenhaver and Bigelow have accomplished a monumental task in collecting together in a most attractive form all the Reppe acetylene work, and their book is a "must" for all chemists and chemical engineers.

SYMPOSIUM FOR NEW JERSEY

The New Jersey Section of A.I.Ch.E. will hold a one-day symposium at the Essex House, Newark, N. J., May 9, 1950. Two sessions are planned. At Session No. 1, Agitation and Mixing, W. E. Lobo will preside and at Session No. 2, General Technical Session, N. Morash will preside.

Speakers and their subjects are as follows:

Session No. 1

Mixing Symposium

9:30 A.M. Common-sense Approach to Mixing Problems—Gordon MacLean, Allied Food Industries, Inc., Perth Amboy, N. J.

10:10 A.M. The Use of Pilot Plant Mixing Data—J. Henry Rushton, Illinois Institute of Technology, Chicago, Ill.

10:50 A.M. The Efficiency of Mechanical Agitators—Darrel E. Mack, Lehigh University, Bethlehem, Pa.

11:30 A.M. Mixing in Axially Symmetrical Jets—Hoyt C. Hottel, Massachusetts Institute of Technology, Cambridge, Mass.

Session No. 2

General Technical Papers

1:30-2:10 P.M. Annual Business Meeting—Election of Officers

2:10 P.M. Engineering Materials—Recent Developments and Trends—Ward R. Myers, Du Pont Co.

2:50 P.M. The Most Persistent Pumping Problems for Chemical Plant Designers—Irving Taylor, The Lummus Co.

3:30 P.M. Addition Compounds of Urea and Organic Substances—Russell W. Millar, O. Redlich, A. E. Smith, C. M. Gable, A. K. Dunlop, Shell Development Co., Emeryville, Calif.

4:10 P.M. Measuring Sticks for the Evaluation of Engineering Enterprises—Lester R. Steffens, Socony-Vacuum Laboratories, Paulsboro, N. J.

BROOKLYN POLYTECHNIC RECEIVES GRANT

The Research Corporation of New York has made a grant of $5,500 to Polytechnic Institute of Brooklyn in support of a $6,800 research project (1950-51) on the study of plate efficiency in distilling columns under the direction of Ju Chin Chu, associate professor of chemical engineering at Polytechnic.

Two predoctoral fellowships for the project are now available at the annual stipend of $2,000.

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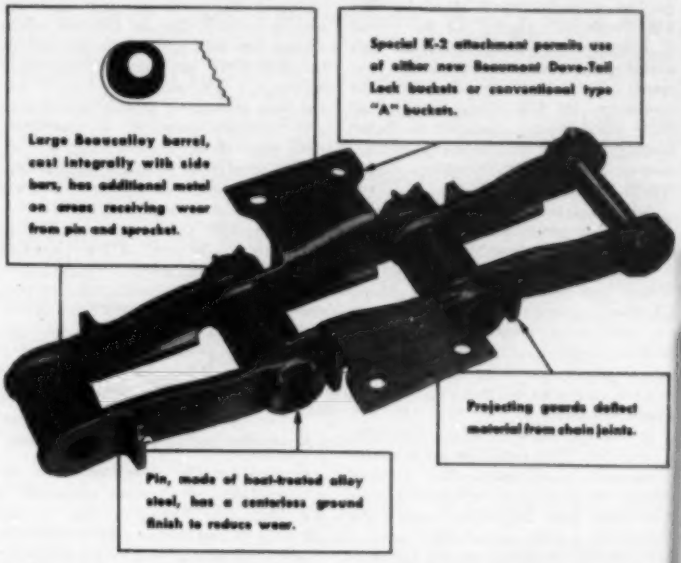

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SECRETARY'S PAGE

S. L. TYLER

The Executive Committee acting on behalf of Council, met in the Office of the Executive Secretary, March 9, 1950. The Treasurer's report for the month of February was accepted and all outstanding bills were approved for payment. The recommendation of the Committee on Admissions to elect all those whose names appeared on Ballot Listing No. 135 was received and accepted. Names of the members elected appear below.

Additional committee personnel were appointed to some of the standing committees of the Institute.

Student Chapters at the University of Maine and the University of South Carolina received the official approval of the Institute. R. E. Durst was appointed student chapter counselor at the University of Maine and B. L. Baker was appointed counselor at the University of South Carolina.

It was the decision of the Executive Committee, after receiving informal endorsement by Council, that a letter should be circulated to Local Section Chairmen and Secretaries suggesting that each section submit the name of one possible candidate for the Office of Director. Names of the suggested nominees will be published in the August issue of *Chemical Engineering Progress*. This new procedure, it is hoped, will be of assistance in the selection of nominees for the Office of Director. The reason for this experiment is that in the past there has been evidence of a wasting of nominating votes as it has not been uncommon to have as many as 200 members suggested as candidates with only about 10 receiving the requisite number of votes for nomination.

J. H. Rushton was appointed Institute representative to attend the Fifth Annual National Conference on Higher Education to be held at the Congress Hotel in Chicago, April 17-19, 1950.

The Executive Committee accepted the recommendation of the Ethics Committee that the Canons of Ethics for Engineers as prepared by the Engineers' Council for Professional Development be printed in the 1950 Year Book.

Amendments to the Constitution

Voting on the amendments to the Constitution, which were discussed at the Business Meeting at the Annual Meeting in Pittsburgh, closed on March 8 and I am pleased to give the following abstract of the report of the Tellers Committee:

Amendment *A*	1266	181
Amendment *B*	1231	215
Amendment *C*	1210	236
Amendment *D*	1353	91
Amendment *E*	1303	142

All these amendments immediately become a part of the Constitution as the vote received was well over the required 20% of the Active membership and the votes in favor well over 75% of those received, which are the conditions outlined in Article IX of the Constitution.

Transactions on Microcards

Vol. 1-10 and the 1929 Index covering Vol. 1-15 of the *Transactions* of the American Institute of Chemical Engineers are now available on microcards. J. S. Canner & Co., Inc., 909 Boylston Street, Boston, Mass., have prepared these cards and offer them for sale at $26.00 for the complete set of 98 cards. Up to 40 Transaction pages are reproduced per individual microcard. Special readers are available from J. S. Canner & Co., Inc., but it is also stated that these may be easily read by use of any modern flat field binocular microscope. Orders for these should be placed directly with the J. S. Canner & Co., Inc., not through the Secretary's Office.

NEW A.I.Ch.E. MEMBERS ELECTED MARCH 9, 1950

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Alan Beerbower
R. E. Bley
Kennard F. Borden
Clifford C. Burton
R. W. Cairns
M. R. Cannon
George T. Cooper
John Delaplaine
Paul Ferencz
A. Robert Fowler
Walter Godchaux, Jr.
Henry C. Gudebski
Byron J. Haley
Courtland M. Henderson
L. B. Parish
Michael G. Pelipetz
Ward E. Pratt
Cedric D. Quimby
Stanley H. Rose, Jr.
Hubert Royer
Jack R. Stuetz
Robert Lee Taylor
Frederick L. Trowbridge
Sterling N. Vines
Heinz P. Weber
L. A. Webber

ASSOCIATE MEMBERS

W. P. Armstrong
Franklin C. Johnson
William Kenda
Alois X. Schmidt
Ralph Carlisle Smith

JUNIOR MEMBERS

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K. V. Antony
Thomas F. Barnhart
George N. Beaumariage, Jr.
Arthur B. Blake
Jack W. Blanton
James L. Buhler
Robert L. Burke
Earnest D. Campbell
Wayne L. Chase
Joseph S. Chirtel
Herman L. Davis
Leon A. LeBauche
D. G. Demianiw
Donald H. Francis
Maurice J. Gifford
Irwin J. Groce
Harry R. Hanson
J. Hernandez-Fragoso
Ervin C. Harney
Wilbur L. Hayne, Jr.
Stuart V. Heil
Karlton J. Hickey
Edwin A. Hicks
Albert B. Horn, Jr.
Jimmie L. Huitt
John C. Jackson
David H. Johnston, III
Charles A. Judge
F. Kutaydim
William Ray Loomis
L. L. Mahone
Mario A. Marcucci
Eugene M. McEachin
Charles E. Meginnis
Edward H. Mellinger
Nicholas Melucci
E. David Metz
Robert W. Michaels
G. Modak
Ralph A. Morgen, Jr.
Paul L. Page
Richard W. Pease
James W. Pervier
Marvin A. Prosche
George S. Reichenbach, Jr.
J. Tom Roberts, Jr.
Horace T. Robson
Joel N. Rossen,
Jack E. Summerville
V. O. Thomas
David A. Trageser
George E. Trent, Jr.
Arthur W. Werry

CANDIDATES FOR MEMBERSHIP IN A.I.Ch.E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 7, of the Constitution of A.I.Ch.E. which states:

Election to membership shall be by vote of the Council upon recommendation of the Committee on Admissions. The names of all applicants who have been approved as candidates by the Committee on Admissions, other than those of applicants for Student membership, shall be listed in an official publication of the Institute.

If no objection is received in writing by the Secretary within thirty days after the mailing date of the publication, they may be declared elected by vote of Council. If an objection to the election of any candidate is received by the Secretary within the period specified, said objection shall be referred to the Committee on Admissions, which shall investigate the cause for each objection, holding all communications in confidence, and make recommendations to the Council regarding the candidate.

Objections to the election of any of these candidates from Active Members will receive careful consideration if received before *May 15, 1950*, at the Office of the Secretary, American Institute of Chemical Engineers, 120 East 41st St., New York 17, N. Y.

APPLICANTS FOR ACTIVE MEMBERSHIP

Seymour P. Bingham, *Winchester, Mass.*
Martin Buck, *Larchmont, N. Y.*
Henry P. Callahan, *Fairfield, Conn.*
R. Chelminski, *New York, N. Y.*
Robert A. Cooley, *Rolla, Mo.*
William W. DaLee, *Birmingham, Mich.*
Robert M. Fought, *Munster, Ind.*
Lewis Gross, *Corpus Christi, Tex.*
K. A. Hanover, *Westfield, N. J.*
Joel O. Hougen, *Troy, N. Y.*
Louis H. Huth, *Sugar Creek, Mo.*
Thomas H. Insinger, Jr., *Monaca, Pa.*
Frank Kral Kaluha, *Bethayres, Pa.*
Robert E. Latimer, *Kenmore, N. Y.*
Walter F. Meister, *Elizabeth, N. J.*
H. Philip Orem, *Plainfield, N. J.*
Robert E. Pahler, *St. Louis, Mo.*
Alfred G. Parker, *Summit, N. J.*
L. Albert Pierce, *Woodward, Ala.*
M. J. Portanova, *Jersey City, N. J.*
George P. Quinn, *Pearl River, N. Y.*
Edward B. Seaton, *St. Louis, Mo.*
Clyde K. Smith, *San Francisco, Calif.*
Harold W. Sohns, *Laramie, Wyo.*
W. L. Stafford, *Newport, Del.*
Frank L. Steahly, *Oak Ridge, Tenn.*
Paul B. Stewart, *Los Angeles, Calif.*
C. Marsden Vanderwaart, *Bound Brook, N. J.*
Peter C. Weinert, *Chicago, Ill.*
Charles A. Wolbach, Jr., *South Amboy, N. J.*
William B. Yarborough, *Collingswood, N. J.*
W. Wallace Yeandle, *Pittsburg, Kan.*

APPLICANTS FOR ASSOCIATE MEMBERSHIP

C. A. Carlson, *Lompoc, Calif.*
Moosen Kwauk, *Bombay, India*
George A. Lenaeus, *Roanoke, Va.*
William F. Robinson, *North Tonawanda, N. Y.*
J. Frank Seely, *Raleigh, N. C.*
Edward G. Spinks, *Indianapolis, Ind.*

APPLICANTS FOR JUNIOR MEMBERSHIP

I. T. Barfod, *New Orleans, La.*
Virgil J. Berry, Jr., *Pasadena, Calif.*
Ruth Blumberg, *Pretoria, S. Africa*
William M. Borr, *Park Forest, Ill.*
Lathan H. Collins, Jr., *Texas City, Tex.*
Leonard A. Cullo, *Troy, N. Y.*
Andrew J. Dahlke, *Philadelphia, Pa.*
Grant F. Davis, *Kenmore, N. Y.*
William M. Deviny, Jr., *Carlsbad, N. M.*
Stephen S. Dorn, *N. Arlington, N. J.*
Barrett S. Duff, *Cambridge, Mass.*
Richard E. Dunning, *Madison, Wis.*
Theodore H. Eklof, *Huntington Park, Calif.*
James F. Ferrel, *Brownsville, Tex.*
T. W. Fisher, Jr., *Elverson, Pa.*
David H. Forrester, *New York, N. Y.*
Frank A. Fuentes, *Bartlesville, Okla.*
William R. Fullem, *Baltimore, Md.*
Raymond M. Glueck, *Roselle, N. J.*
Harold A. Golle, *Clifton, N. J.*
William J. Hanlon, Jr., *Phillipsburg, N. J.*
John E. Hanway, Jr., *Fairmont, W. Va.*
Richard B. Hillman, *Wynnewood, Pa.*
Harold L. Hoffman, *Houston, Tex.*
Lewis C. Hullinger, *Whiting, Ind.*
Arthur Humphrey, *Moscow, Idaho*
Arthur H. Isaacs, *Louisville, Ky.*
William F. Kieschnick, Jr., *Dallas, Tex.*
Harry A. King, *San Francisco, Calif.*
V. Krishnamurthi, *Alwaye, S. India*
Walter C. Lapple, *Westport, Conn.*
Louis M. Levy, *Miamisburg, Ohio*
Donald R. Lindahl, *Frederick, Md.*
Richard Lord, *Charleston, W. Va.*
Joseph Magliolo, Jr., *Texas City, Tex.*
Andrew P. Martin, III, *Birmingham, Ala.*
Thomas V. McGannon, *Texas City, Tex.*
Arthur B. Metzner, *Brighton, Mass.*
Stephen J. Miller, *New York, N. Y.*
Robert F. Nacci, *Wallingford, Conn.*
Joseph Novack, *Oakdale, L. I., N. Y.*
Whitney L. Pearson, *North Chicago, Ill.*
Roy A. Pollock, *Terre Haute, Ind.*
James E. Rice, *Schenectady, N. Y.*
Matthew L. Rue, Jr., *Princeton, N. J.*
David I. Saletan, *Ann Arbor, Mich.*
Navin P. Shah, *Louisville, Ky.*
K. J. Soderstrom, *Oak Park, Ill.*
Charles E. Spear, *Monsanto, Ill.*
Chester R. Stipe, *Martinez, Calif.*
Dale M. Strasser, *Montebello, Calif.*
John F. Tourtellotte, *Chicago, Ill.*
Wayne E. Wells, *Rifle, Colo.*
Jack Robert Westlund, *Chicago, Ill.*
Howard G. Wittmer, Jr., *Toledo, Ohio.*

HOUSTON MEETING

(*Continued from page 22*)

season's operation, some 2,000 hr., resulted in a product with a market value of $1,375,000. Total cost of one season's operation plus the cost of the new plant was not more than $500,000. This is admittedly an unusually profitable illustration.

One of the meeting highlights was the Chlorine-Alkali Symposium with Carl F. Prutton, Mathieson Chemical Corp., presiding over a series of five papers.

Roberts Winner of Award

C. P. Roberts, Food Machinery & Chemical Corp., was presented the Institute Award for the best presented paper at the Houston meeting. His subject was "Electrolytic Recovery of Chlorine from Hydrogen Chloride," and was one of those in the Chlorine-Alkali Symposium. Mr. Roberts dealt wtih the chlorine-alkali chemical engineer's quest for the "philosopher's stone"—not a method of converting base metals into gold—but a method for making chlorine without caustic and still compete with the price of electrolytic chlorine. Mr. Roberts had a partial answer in the electrolysis of cupric chloride in hydrochloric acid. The cupric ion is reduced

(*Continued on page 45*)

Left: Joe Young, Infilco, Inc., and Jim Lee, "Chemical Engineering." Public Relations Committee; Right: W. T. Richard and O. T. Fasullo, Consolidated Chemical Industries, Inc., Hotel and Meeting Room Committee.

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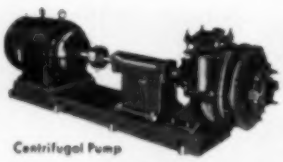

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LOCAL SECTIONS

CHARLESTON, W. VA.

A general meeting of this section was held at the North Charleston Recreation Center, March 21, 1950; 170 members and guests were present. The local chapter of the American Society of Mechanical Engineers was given a special invitation to attend this meeting, and a number from this group were present.

The speaker of the evening was Adolph O. Schaefer, assistant to the executive vice-president, the Midvale Co. His subject was "Metallurgy and Design of Forged Pressure Vessels." Mr. Schaefer presented a series of slides to illustrate the steps in the manufacture of large hollow forgings. He stated that the principal problem limiting the size of forgings is one of transportation within or outside the manufacturing plant and not one of press capacity. Ingots weighing as much as 300 tons can be handled satisfactorily in present equipment, from which forgings weighing up to 150 tons can be produced. Mr. Schaefer also discussed types of steel used for making forgings.

A general meeting was held at the Daniel Boone Hotel, Feb. 21. Dinner was served to 177 members and guests.

The speaker of the evening was Dr. Warren K. Lewis, professor emeritus of chemical engineering at Massachusetts Institute of Technology. His subject was "Engineering as a Profession." A professional person differs from a technician, according to Dr. Lewis, primarily in that he has full responsibility in dealing with problems in his area of influence, whereas the technician has no such responsibility.

Reported by R. W. King

BOSTON (Ichthyologists)

The Feb. 24 meeting heard Dr. Leroy N. Vernon discuss "Can Psychology Predict Human Behavior?" Doctor Vernon, director of the Personnel Laboratories in Chicago, Ill., described the factors making up general intelligence, personality traits and their relationships with aptitudes and vocational interests.

A series of special tests combined with interviews is used to give enough insight into a person's psychological make-up to warrant prediction of his performance on a given job. The approach is particularly valuable if an entire organization is tested at once.

Prolonged discussion indicated the appeal of the subject and the desire of chemical engineers to learn more about application of psychological techniques.

Reported by Henry Avery

OHIO VALLEY

This section on March 6, had a joint meeting with the local section of A.S.M.E. at the Herman Schneider Foundation Building in Cincinnati. Max Leva, consulting engineer, presently located at Pittsburgh, Pa., gave an informative discussion entitled "Fluidization Applied to Unit Processes."

At the monthly meeting of this section held Feb. 6, Henry H. Kranz, city engineer of Cincinnati, gave a talk on Cincinnati's sewage disposal problems. Mr. Kranz discussed the proposed ordinance which will be considered by the Cincinnati council; this ordinance will set up the specifications for the limits of acceptance of wastes in the Cincinnati pool of the Ohio River and the effect of these specifications on local industry.

Officers of this section for 1950 are as follows:

Chairman—R. C. Head, Procter and Gamble Co.
Vice-Chairman—Alexander C. Brown, Emery Industries
Secretary—Arthur C. Greber, Schenley Distilleries
Treasurer—Raphael Katzen, Vulcan Copper & Supply Co.

Reported by A. C. Greber

EL DORADO CHEMICAL ENGINEERS' CLUB

The second dinner-speaker meeting of the recently organized El Dorado Chemical Engineers' Club was held in El Dorado, Ark., Feb. 16. In attendance were 77 members and guests.

F. Robert Mendow, boiler specialist, A. M. Lockett Co., New Orleans, La., talked on "Industrial Boilers." With the aid of a movie and photographs, various phases of boiler design, construction and operation were outlined; emphasis was placed on such factors as operating efficiency and safety.

Reported by C. H. Davenport

WESTERN NEW YORK

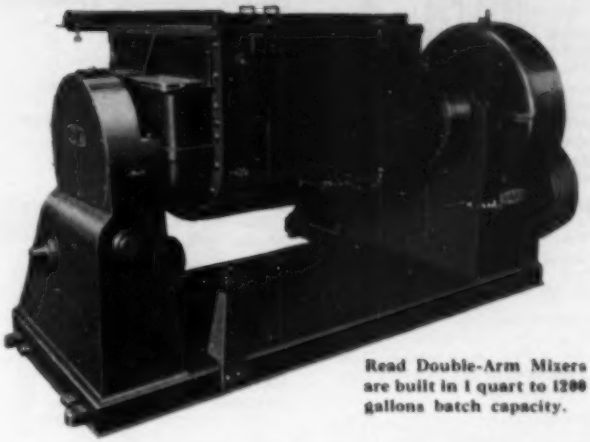
This section held a meeting at the Prospect House, Niagara Falls, March 16. About 80 members and guests were present.

Dr. C. G. Kirkbride, vice-president in charge of research, Houdry Process Corp., Marcus Hook, Pa., the speaker of the evening, was introduced by R. L. Murray, a current director of the Institute. Dr. Kirkbride talked on the development and current competitive position of the Houdriflow Catalytic Cracking process.

Reported by E. C. Mirus

(*Continued on page 40*)

MIXING CYCLE *Speeded Up*
PEAK LOADS MINIMIZED



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FUTURE MEETINGS AND SYMPOSIA OF A.I.Ch.E.

Chairman of the A.I.Ch.E. Program Committee

George E. Holbrook

Room 7406 Nemours Bldg.,
E. I. du Pont de Nemours & Co.,
Wilmington, Del.

MEETINGS

Regional — Swampscott, Mass., New Ocean House, May 28-31, 1950.

Technical Program Chairman: R. L. Geddes, Stone & Webster Eng. Corp., Boston, Mass.

Co-Chairman: E. R. Gilliland, Massachusetts Institute of Technology, Cambridge, Mass.

Regional — Minneapolis, Minn., Radisson Hotel, Sept. 10-13, 1950.

Technical Program Chairman: E. L. Piret, Minnesota Mining & Mfg. Co., Minneapolis, Minn.

Annual—Columbus, Ohio, Neal House, Dec. 3-6, 1950.

Technical Program Chairman: John Clegg, Battelle Memorial Institute, Columbus, Ohio

Regional—Kansas City, Mo., Hotel Muehlebach, May 13-16, 1951.

Technical Program Chairman: Walter W. Deschner, J. F. Pritchard Co., Kansas City, Mo.

Annual — Atlantic City, N. J., Chalfonte-Haddon Hall Hotel, Dec. 2-5, 1951.

SYMPOSIA

Indoor vs. Outdoor Plant Construction

Chairman: J. R. Minevitch, E. B. Badger & Sons Co., 75 Pitts St., Boston, Mass.

Meeting—Not scheduled.

Chemical Engineering Fundamentals

Chairman: Mott Souders, Shell Development Co., San Francisco.

Meeting—Minneapolis, Minn.

Chemical Engineering Kinetics

Chairman: R. H. Wilhelm, Princeton (N.J.) University

Meeting—Minneapolis, Minn.

Chemical Engineering in Food Industries

Chairman: W. L. Faith, Corn Products Refining Co., Argo, Ill.

Meeting—Minneapolis, Minn.

Phase Equilibria

Chairman: W. C. Edmister, Carnegie Inst. of Tech., Pittsburgh, Pa.

Meeting—Minneapolis, Minn.

Fluidized Systems in Chemical Syntheses

Chairman: E. R. Gilliland, Massachusetts Institute of Technology, Cambridge, Mass.

Meeting—Swampscott, Mass.

Ultrasonics

Chairman: Dudley Thompson, Virginia Polytech. Inst., Blacksburg, Va.

Meeting—Swampscott, Mass.

Applied Thermodynamics

Chairman: James Coull, University of Pittsburgh, Pittsburgh, Pa.

Meeting—Not scheduled.

Chemical Engineering in Glass Industry

Chairman: F. C. Flint, Hazel-Atlas Glass Co., Washington, Pa.

Meeting—Not scheduled.

Processing of Viscous Materials

Chairman: W. W. Kraft, The Lummus Co., New York, N. Y.

Meeting—Not scheduled.

Air and Water Pollution Control

Chairman: Richard D. Hoak, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

Meeting—Columbus, Ohio

Authors wishing to present papers at a scheduled meeting of the A.I.Ch.E. should first query the Chairman of the A.I.Ch.E. Program Committee, George E. Holbrook, with a carbon copy of the letter to the Technical Program Chairman of the meeting at which the author wishes to present the paper. Another carbon should go to the Editor, F. J. Van Antwerpen, 120 East 41st Street, New York 17, N. Y. If the paper is suitable for a symposium, a carbon of the letter should go to the Chairman of the Symposia, instead of the Chairman of the Technical Program, since symposia are not scheduled for any meeting until they are complete and approved by the national Program Committee. Before authors begin their manuscripts they should obtain from the meeting Chairman a copy of the Guide to Authors, and a copy of the Guide to Speakers. The first book covers the preparation of manuscripts, and the second covers the proper presentation of papers at A.I.Ch.E. meetings. Presentations of papers are judged at every meeting and an award is made to the speaker who delivers his paper in the best manner. Winners are announced in *Chemical Engineering Progress*, and a scroll is presented to the winning author at a meeting of his local section. Since five copies of the manuscript must be prepared, one should be sent to the Chairman of the symposium and one to the Technical Program Chairman of the meeting, or two to the Technical Program Chairman if no symposium is involved and the other three copies should be sent to the Editor's office. Manuscripts not received 70 days before a meeting cannot be considered.

LOCAL SECTION NEWS

(Continued from page 39)

AKRON

The March meeting was held at the University Club and was attended by about 60 members and guests.

Donald Hayes announced that refresher courses were being offered this year to those individuals who wish to prepare for examinations which are required to register as Professional Engineers in the State of Ohio.

A film titled "Behind the Checkered Flag" was shown. This was a documentary on the preparation of racing cars for the Indianapolis Speedway races.

Dr. R. C. Gunness, manager of research of Standard Oil Company (Ind.), spoke to a group on synthetic fuels. He outlined the various sources of synthetic fuels and described their present state of development. He stated that synthetic fuels will not be needed in this country for at least a decade except for a limited demand of special by-products and stated that if discoveries of new petroleum fields continues at present rate of discovery it may be many more years before synthetic fuels will be necessary. Based on extensive studies he also stated that synthetic fuels will be much higher in cost than those obtained from present petroleum sources.

Reported by J. W. Kosko

OKLAHOMA

This section met Feb. 16, 1950, at 7:30 P. M. in the auditorium of McKinley School in Bartlesville. The attendance was 105 members and guests. Fred L. McAulay of Westinghouse spoke on the subject of the gas turbine. Illustrating his talk with slides and motion pictures, Mr. McAulay explained that 28 engineers and 14 mechanics, average age 30 years, developed and produced a turbo-jet engine in 1½ years using no previous research work that was available from foreign countries. Motion pictures were shown to illustrate the use of the gas turbine to power two aircraft, the Voodoo and the Banshee jet planes.

Reported by George E. Hays

CHICAGO

This section heard Warren L. McCabe, President of A.I.Ch.E., as dinner speaker at the February meeting. More than 80 members were in attendance. Dr. McCabe spoke on "A.I.Ch.E.—Its Management and Objectives." Emphasis was placed on the potentialities of the national organization and what it can do for its members if all individuals and local sections will undertake a more active participation.

Reported by Donald A. Dahlstrom

ST. LOUIS

This section is sponsoring a one-day Regional Symposium on Professional Guidance for Chemical Engineers May 5, 1950, at the Hotel DeSoto, 1014 Locust St., St. Louis, Mo. The morning session beginning at 9 A.M. will be devoted to "Careers in Chemical Engineering," under the chairmanship of Dr. L. E. Stout, Sever Institute of Technology, Washington University. The afternoon session beginning at 2 P.M., under the chairmanship of W. T. Nichols, Monsanto Chemical Co., will be devoted to some "Unit Chemical Engineering Processes." Program is:

Morning Program

1. **Careers in Engineering**— Address *Dr. T. H. Chilton—Du Pont*
2. **Progress in Engineering Careers**—A series of short talks by engineers out of schools from one month to ten years.
   John Sauer—Washington University
   Henry Demey—Proctor and Gamble
   Marvin Marsh—Mallinckrodt
   Ken Carpenter—American Zinc
3. **Spheres of Activity for Chemical Engineers**—A series of short talks on the subjects listed below.
   a. **Teaching**—*Speaker, Dr. Chamberlain, Washington University*
      Panel, Professors Lorah, University of Missouri; Conrad, Rolla School of Mines
   b. **Research and Development**—*Speaker, Dr. Fellinger, Monsanto*
      Panel, J. Newsome, Aluminum Ore Co.; R. Brickenkamp, National Lead
   c. **Process Engineering**—*Speaker, F. Holzapfel, Monsanto*
      Panel, C. Swartout, Mallinckrodt; Joe Lettier, Shell Oil
   d. **Production**—*Speaker, C. Smith, Aluminum Ore Co.*
      Panel, L. P. Davidson, American Zinc; R. Hemminghaus, Monsanto
   e. **Sale of Chemical Equipment**—*Speaker, Bruce Greaves*
      Panel, C. Dean, Monsanto; L. Lopata, Process Eng. & Eqpt.
   f. **Place of Engineer in Small Business**—*Speaker, H. E. Wiedemann, Consultant*
      Panel, W. Kelley, Monsanto; A. Winheim, Planetary Chemist

Afternoon Program

1. **Crushing, Grinding and Drying**
   a. **Coarse Crushing and Grinding**—*E. Jueckstock, Williams Patent Crusher and Pulveriser Co.*
   b. **Fine Grinding and Drying**—*A. R. Jenny, Raymond Pulverizer Division of Combustion Engineering*
   c. **Panel Discussion**—*Messrs. Jueckstock and Jenny*
2. **Mixing of Liquids**
   a. **Selection of Mixers for Estimating Purposes**—L. H. *Mahony, Mixing Equipment Co.*
   b. **Place of Turbine in Agitation**—*A Talk by Elliot Page, New England Tank & Tower Co.*
   c. **Panel Discussion**—*Messrs. Mahony and Page.*

Reported by R. C. Roberts and R. S. Yates

(Continued on page 42)

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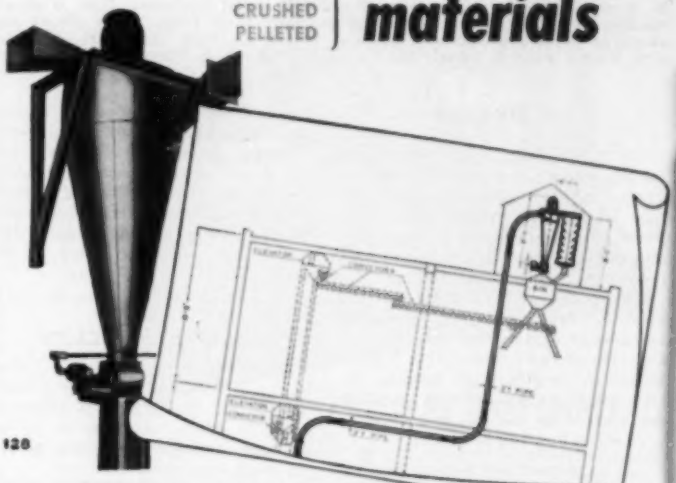

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 (Continued from page 41)

COLUMBIA VALLEY OFFICERS

B. E. Greffrath, former chairman, Richland Chemical Engineers' Club, is shown handing the gavel to the section's new chairman, H. S. Isbin. Other officers and executive committee members look on. Seated (in usual order): H. S. Isbin, A. S. Mowry, and S. S. Jones. Standing: B. E. Greffrath, G. Thayer, B. Weidenbaum, and C. E. Kent.

ROCHESTER

The fifth meeting of the 1949-50 season was a joint meeting with the Student Chapter of the University of Rochester held March 15, at the Faculty Club. About 50 students, members, and guests attended the dinner, and 72 attended the regular meeting in Lattimore Hall.

The speaker of the evening was Dr. Barnett F. Dodge, chairman, department of chemical engineering, Yale University. Dr. Dodge's topic, "Our Energy Resources," dealt with all forms of energy which are available on the earth and covered the methods and efficiency with which they can be utilized.

Reported by Earl W. Costich

ROCKY MOUNTAIN

The regular February meeting of this section was devoted to sponsorship of a "Student Meeting-in-Miniature"; participants were chemical engineering students from the nearby student chapters at the University of Colorado and University of Denver. The purpose of the event, held Feb. 25 on the campus of the University of Denver, was to afford student engineers opportunity for written and oral presentation of technical papers, in the manner, form, and under rules similar to those employed for the National A.I.Ch.E. conventions.

Winning papers in each class included John W. Pringle (graduate), University of Colorado (Pulp and Paper Making Prospects in Colorado), and Daniel P. Veldorale (undergraduate), University of Denver (Market Survey and Study of Production Costs for a Mixed Fertilizer Grade 15-30-5). Prizes of $20 each were awarded from funds provided by interested industrial concerns in the Rocky Mountain region. The success of the meeting has prompted the section's executive committee to install it as an annual event.

Speaker at the award luncheon following the morning technical session was Dr. Raymond Ewell, head, department chemistry and chemical engineering, Stanford Research Institute. His subject was, "What's Ahead in the Chemical and Process Industries."

Reported by Charles H. Prien

COLUMBIA VALLEY

The newly formed Columbia Valley Section of A.I.Ch.E. held its first meeting Jan. 31. The group was addressed by W. E. Johnson, manager of the design and construction divisions of the General Electric Co.'s Nucleonics Department. The topic of Mr. Johnson's talk was "Engineering and Philosophy." Dr. R. H. Beaton, manager of the separations technology division at Hanford Works (General Electric Co.), spoke briefly, outlining the broad program and objectives for local sections as set forth by the Institute.

On Feb. 28 the section held a joint meeting with the Richland Section of The American Chemical Society. About 250 chemists and engineers attended the joint meeting, to hear a lecture by Prof. Glenn T. Seaborg, of the University of California (Berkeley), on "High-Energy Nuclear Reactions."

Both meetings were held in Richland, Wash.

The Columbia Valley Section serves chemical engineers residing east of the Cascade Mountains in the State of Washington and in the northern part of Idaho. In 1949, before being recognized as a Local Section of the Institute, the group functioned informally as the Richland Chemical Engineers' Club, under the chairmanship of B. E. Greffrath.

The officers of the section are:

Chairman.....H. S. Isbin
Vice-Chairman.....A. S. Mowry
Sec'y-Treas.....S. S. Jones
Chairman (Publicity Committee) George Sege
Executive Committee—B. E. Greffrath, C. E. Kent, G. Thayer, and B. Weidenbaum in addition to officers who serve *ex officio*.

Reported by George Sege

ROCHESTER OFFICERS AND SPEAKER

Left to right: H. G. Cook, treasurer; E. E. Mohr, vice-chairman; B. F. Dodge, speaker at March meeting, and O. E. Dwyer, chairman.

DETROIT JUNIOR GROUP

This group met March 7 and listened to three members of the group give short talks. S. S. Lamba, of Pennsylvania Salt, spoke on "Chemical Engineering in India" in which he included some views on the economic situation in India. Joseph Adinoff, of Parke, Davis and Co., discussed "Chemical Engineering Applications in the Pharmaceutical Industry," and Robert E. Cavanaugh, of Sno-Flake Products Co., talked about "Automotive Body Polishes."

Reported by P. A. Lenton

PITTSBURGH

Any large-scale development of technically feasible synthetic fuels processes must await a favorable economic climate when considering future trends in the liquid fuels economy of the United States. This was the theme of an address by Dr. R. C. Gunness, manager of research, Standard Oil Co. (Ind.), at the March dinner meeting held at the College Club of Pittsburgh.

Dr. Gunness reviewed the current technical status of the principal synthetic fuels processes under development in this country by private industry and the Bureau of Mines. He pointed out that the national supply-demand picture in liquid fuels had altered greatly since the period 1945-48, following World War II, in which depleted inventories were being replenished.

Problems besetting the young engineering graduate in today's employment buyers' market were highlighted by Dr. Everett P. Partridge in his keynote address at Mellon Institute auditorium, Feb. 17, before senior chemical engineering students of Pittsburgh and district colleges and universities, including delegations from Penn State College and West Virginia University. At this "Student Night," sponsored annually by this section, the speaker who is director of research for Hall Laboratories, Pittsburgh, appropriately titled his subject "Who's Confused."

He outlined the many methods by which the technical job-seeker can map out his personal campaign.

Reported by Hugh L. Kellner

LOUISVILLE

At its March meeting this section heard C. F. Paulson discuss ion-exchange resins. Mr. Paulson, research department, Permutit Co., presented briefly the fundamentals of the ion-exchange process.

John G. Dobson, Foxboro Co., will speak on instrumentation at a combined meeting of this section and the local section of the Instrument Society of America, April 19, in the Speed Scientific School auditorium.

Reported by W. B. Altsheler

(Continued on page 44)

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LOCAL SECTION NEWS

(*Continued from page 43*)

TENNESSEE VALLEY

This section met in the conference room at the TVA Fertilizer Works, Feb. 20, 1950, to hear Kenneth Watson, assistant director, Ohio River Valley Water Sanitation Commission, speak on "Pollution-Control Action in the Ohio Valley."

Mr. Watson stated that the commission is an organization set up by the signatory states to control pollution of the Ohio River. Thus far eight states of the Ohio drainage basin have joined and three more—Alabama, Tennessee, and North Carolina—are eligible but have not yet become members. The fundamental responsibility of a state as to control of pollution within its own boundaries is recognized. It is in control of pollution originating in one state but seriously affecting others that the commission plays its role. It also coordinates research on common problems and is available for advice on intrastate problems. Thus far sanitary studies have been made in the Cincinnati (Ohio); Pittsburgh (Pa.); and Huntington (W. Va.) areas.

Reported by Gordon Stoltz

KANSAS CITY

On March 15 this section sponsored a panel of seven chemical engineers who spoke at the Kansas University Student Chapter at Lawrence, Kan., on "Job Opportunities for the Chemical Engineer." Each member on the panel spoke on his particular phase of chemical engineering. The chemical engineers, and their subject, who served were:

L. V. Sorg, Standard Oil Co. (Ind.)—Research
W. W. Niven, Midwest Research Institute—Development
C. W. Nofsinger, The Nofsinger Co.—Process Engineering
I. C. Staeuble, Standard Oil Co. (Ind.)—Operations
H. M. Hart, Standard Oil Co. (Ind.)—Technical Service
B. F. Wobker, Phillips Petroleum Co.—General Engineering
R. F. Brown, Union Carbide and Carbon—Sales
V. V. Valleroy, Kansas University—Moderator

Reported by I. E. Miller

PHILADELPHIA-WILMINGTON

At the meeting of the section on Feb. 14 at Clubhouse Hotel, Chester, Pa., Sidney D. Kirkpatrick, editor, and a former president of A.I.Ch.E., spoke on "Communication as a Chemical Engineering Operation." Attendance 65, with 51 at the dinner preceding.

Reported by R. B. Chillas, Jr.

PERSONALIA

F. G. SAWYER WITH STANFORD RESEARCH

Dr. Frederick G. Sawyer, editorial representative of the eleven western states for the American Chemical Society, recently joined the staff of Stanford (Calif.) Research Institute. His primary assignment will be the administration of the Institute's Air and Water Pollution Research program, according to an announcement by Dr. J. E. Hobson, director. He will also consult on special problems in chemistry and chemical engineering research.

Dr. Sawyer has had his headquarters in San Francisco since the spring of 1946, when he set up the ACS's editorial offices there. He has been associate editor of two ACS monthly publications, *Chemical and Engineering News* and *Industrial and Engineering Chemistry*.

He has his Bachelor's, Master's and Ph.D. degrees in chemical engineering from the Polytechnic Institute of Brooklyn. The Chemists' Club of New York awarded him its Bloede Scholarship for his doctorate studies. It was the first time the scholarship was given to a chemical engineer.

For two years Dr. Sawyer was with the American Cyanamid Co.'s central research laboratory at Stamford, Conn. His work there was colloidal studies on suspensions of resins used in paper manufacture. Later he was transferred to the company's New York offices, where he was with the technical service department.

In the fall of 1946 Dr. Sawyer went to Washington, D. C., and spent seven months with the research and development division of the War Department's general staff.

Hart U. Fisher is now control engineer, Niagara Blower Co., New York, N. Y. He was plant instrument engineer with Monsanto Chemical Co. for 17 years.

(*Continued on page 46*)

HOUSTON MEETING

(Continued from page 37)

to the cuprous form yielding chlorine. The cuprous chloride is oxidized with air and hydrochloric acid and recycled to the cell. Hydrochloric acid is consumed in the process. The author evaluated the process in conclusion: "Under the circumstances where by-product hydrogen chloride is available, where power costs are low, labor costs are not higher than average, where chlorine is in demand and the caustic soda market is not attractive, this process is believed the most economical one known for producing chlorine."

W. L. Badger, consulting chemical engineer, described a high temperature continuous evaporator for producing 99.5% sodium hydroxide which is heated by Dowtherm vapor. The evaporator is constructed of pure nickel where surfaces are in contact with the caustic and experience has shown there is almost no corrosion of nickel by caustic. Chlorates, he reported, will cause rapid corrosion of nickel and their removal from the evaporator feed must be substantially complete. The discovery of a satisfactory chlorate removal treatment was not without difficulty but, he stated, it is now an accomplished fact.

Student Program

The concluding session of the technical program was a series of four student papers which were selected as the best of thirty submitted. The four authors competed for cash prizes in their presentation before the Houston meeting and E. L. Britt, of Texas A. & M. carried off top honors. Runners up were G. R. Walton, Jr., Rice Institute, J. C. Counts, University of Texas, and Ralph Somers, Texas A. & M. The student program followed a luncheon with some 150 students and professors in attendance. W. K. Lewis of M.I.T. was the guest of honor.

At the Tuesday evening banquet, W. V. Houston, president of Rice Institute, was the principal speaker and chose as his subject, "Engineering and Education."

Plant trips, a regularly scheduled feature of all Institute regional meetings, received priority ratings on the agendas of most visiting chemical engineers. Since the previous meeting of the A.I.Ch.E. in Houston in 1946 expansion of chemical industry in that area has been phenomenal. Trips were made to the Diamond Alkali Co. at Pasadena, the Houston refinery of the Shell Oil Co., the Mathieson Chemical Corp. fertilizer plant at Pasadena, the plant of the Champion Paper & Fibre Co., Pasadena, and the synthetic rubber plant of the Goodyear Synthetic Rubber Corp.

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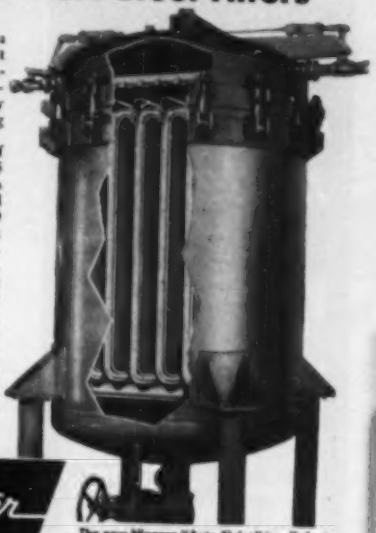

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PERSONALIA

(Continued from page 44)

STANOLIND'S NEW SUPERVISORY APPOINTEES

J. H. Eppard J. C. Weaver, Jr. W. W. Walk D. G. Zink

STANOLIND ANNOUNCES SUPERVISORY POSITIONS

Stanolind Oil and Gas Co. has announced the appointment of several men to fill supervisory positions for Stanolind's new Brownsville (Tex.) chemical plant. Included in this list are four members of A.I.Ch.E.

Dr. Donald G. Zink, general superintendent, chemical products department for Stanolind is in charge of all commercial development and marketing in the field of chemicals. (Reference to Dr. Zink was made in C.E.P. February, 1950, p. 38.) He will remain at the Tulsa general office. Before going to Stanolind in 1947, he was director of technical development for U. S. Industrial Chemicals, Inc.

The plant process supervisor, Joe C. Weaver, Jr., has been with Stanolind since 1947. He received his chemical engineering degree in 1935 from the University of Alabama and worked as a chemist and engineer in his home state of Alabama for a time before accepting a position with the Sherwin Williams Co. in Chicago. He worked as a group leader in chemical process development with the paint company before joining Stanolind as a senior chemical engineer.

John H. Eppard and Warren W. Walk have both been named shift supervisors at Brownsville. Mr. Eppard received his degree in chemical engineering from Kansas State College in 1940 and worked two years with the Sinclair Refining Co. at Houston. Following this he spent 4½ years with the Phillips Petroleum Co. as a process engineer before going to Stanolind in 1947.

Warren Walk received both his Bachelor's and Master's degree in chemical engineering from the University of Missouri, finishing his schooling in 1948. He has been with the research department of Stanolind since his graduation, working as a process engineer in hydrocarbon synthesis and the recovery and purification of by-product chemicals.

MILLER-WARDEN MERGER

J. Strother Miller, formerly technical director of the Barber Asphalt Corp. and now a consultant in asphalt technology, has joined forces with Warren B. Warden, under the name Miller-Warden Associates, as consultants in all phases of asphalt technology.

Mr. Miller has given 40 years of service in the petroleum and chemical fields. He is chairman of Committee *D-8* of the American Society for Testing Materials, and past president of the Association of Asphalt Paving Technologists. Mr. Miller's office is at 63 Bernhardt Drive, Snyder, Buffalo 20, N. Y.

Mr. Warden has been associated with Socony-Vacuum Oil Co., Johns-Manville Corp., Flintkote Co., and Kendall Refining Co. A year ago he returned from Aruba, Netherlands, West Indies, where he was general manager in charge of construction of a new asphalt plant for the Byerlyte Corp. He also is a member of many technical societies. Mr. Warden resides at 731 Yale Ave., Swarthmore, Pa., also the mailing address for Miller-Warden Associates.

Quentin T. Prindle has joined the Columbia chemical division of Pittsburgh Plate Glass Co. as a chemical engineer at the Natrium (W. Va.) plant. A graduate of Case Institute of Technology with a B.S. in chemical engineering, Mr. Prindle formerly was associated with Heyden Chemical Corp. as chief engineer and assistant plant manager at the Memphis works. Other associations were with Pennsylvania Salt Manufacturing Co. and with the Du Pont Co.

John P. Edwards has been named supervisor of product application by Hooker Electrochemical Co., Niagara Falls, N. Y. Mr. Edwards, a chemical engineer, was graduated from the University of Minnesota in 1940, and since going to Hooker that year, has been associated with process study group and more recently with sales development.

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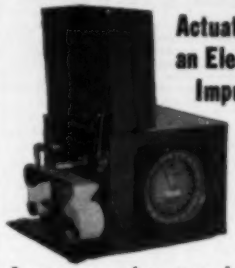

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L. K. HERNDON

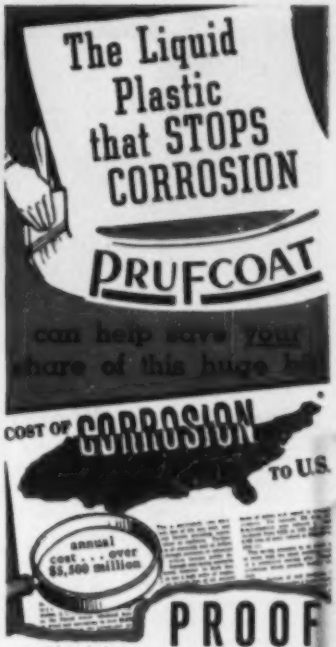
L. K. HERNDON DIR. RESEARCH, MATHIESON

L. Kermit Hernon, professor of chemical engineering at Ohio State University, has been appointed director of research for Mathieson Chemical Corp. His headquarters will be at the company laboratories in Niagara Falls, N. Y., and an office in the Mathieson Building in Baltimore. Consulting engineer to the company prior to his present appointment, Dr. Herndon will continue to hold his university post while completing graduate research assignments and supervising Mathieson's Ohio State University Research Foundation project.

C. W. DEANE

Appointment of Charles W. Deane as general engineering manager of Lever Brothers Co., New York, N. Y., has been announced by William H. Burkhart, vice-president in charge of manufacturing and traffic. Dr. Deane, formerly chief engineer for E. R. Squibb & Sons, will direct engineering operations of all Lever plants, and coordinate new construction projects. He has had long experience in soap industry engineering, and has written extensively on engineering and engineering administration, both mechanical and chemical. He is a member of many technical and scientific societies. The new general engineering manager's offices are at Lever's general offices, 80 Varick Street, New York.

(*Continued on page 50*)



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*Article in C. & E. News Vol. 37 — #39

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Engineer, Physicist or Chemist—With electronics background for technical liaison work between research in textile field and patent attorney. Chemistry and/or mechanical background necessary. Age 25-35. State qualifications and salary expected in first letter, addressed to F. W. Clore, Jr., Technical Division, Rayon Department, E. I. duPont deNemours & Company, Wilmington, Delaware.

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Chemical Engineer—Ph.D., age 34. Thirteen years of diversified and responsible industrial experience covering catalytic cracking, complete refinery design and revamp, atomic energy design, light-ends recovery and oxygenated compounds separation. Strong in distillation, absorption, extraction and adsorption. Experience ranges from process design and development to project engineering. Desire responsible position requiring technical, administrative and organizational ability. Box 1-4.

University Teaching and Research—Position in chemical engineering. Purdue, B.S.Ch.E., 1942; Michigan, M.S., 1943; Ph.D., June, 1950. Two years' industrial experience, four years teaching. Fellowships, societies. Age 29; married. Box 2-4.

Supervisory Chemical Engineer—B.S., 31. Experienced in supervision, operations, pilot plant development, plant design, and economic studies of petroleum and petrochemical plants. Desire responsible engineering position with small company. Box 3-4.

Chemical Engineer—31, M.I.T., 1940, 9½ years' experience process design, plant operation and project engineering with internationally known contracting firm and large oil company, specializing in oil, light hydrocarbons, and petrochemicals. Desire engineering group leadership or similar responsible position with organization planning expansion. Box 4-4.

Executive Engineer—Chemical engineer engaged in direction of group designing plants for soaps, detergents, chemicals, and pharmaceuticals. Seek position as chief engineer. In present position have overall responsibility for projects. Metropolitan area preferred. Box 5-4.

Chemical Engineer—Ph.D. 1949. Family, 31, veteran. Professional engineer Ohio. Five years' experience veg. oil processing; fatty acid pilot plant. Good references. Serious, reliable, quiet worker. Desire production-development; research; prefer organic field. Available now. Box 7-4.

Chemical and Industrial Engineer—36. Production supervisor six years, alkylation, polymerization, esterification, monomers. Five years design of standards in chemical field for standard cost systems. Wish to combine experience in supervisory position. Box 8-4.

Chemical Engineer—M.S.Ch.E., 1947. Married, 31. Credits toward Ph.D. Experience in distillery operation, teaching. Desire process development, pilot plant or production work with responsibility. Available now. Location immaterial. Box 9-4.

Chemical Engineer—Ph.D. Age 31. Almost five years' professional industrial experience in laboratory, pilot plant, and engineering groups. 2½ years' part-time teaching experience. Specialization, organic technology under famous professor. Numerous honorary society and other technical society memberships. Desire industrial research, development, or managerial position or university professorship. Preferred location, Midwest or East (Birthplace, Chicago). Currently holding responsible position in small isolated Southern town as research engineer on multi-million dollar project. Box 10-4.

Chemical Engineer—B.Ch.E., 1947. Married, 25. Two and one-half years' experience in mid-western refinery. One year Navy engineering officer. Consider domestic or foreign employment. Box 11-4.

Chemical Engineer—26. University of Michigan. B.S.Ch.E., M.S.Ch.E. 1948. Two years' experience process improvement, cost analysis, data analysis and correlations, report writing, and pilot plant work. Desire position in development, technical service or production. Box 12-4.

CLASSIFIED SECTION

(Continued)

Chemical Engineer — B.S.Ch.E., 1943. 6½ years' broad industrial experience in research, production, trouble shooting, process engineering, specifications, etc. 29 years old, family. Salary $4,200-$5,000. Box 13-4.

Chemical Engineer—30, M.S.Ch.E. with thesis. Experienced pilot plant development; supervision maintenance, manufacturing, packaging; cost interpretations; report writing. Versatile, energetic, cooperative worker. Prefer customer service, technical engineering. Location immaterial for responsible position. Box 14-4.

Chemical Process Engineer—Exceptional education and experience in production process control and development, including the design of pilot plant equipment, supervision of projects and cost estimates. Have been in responsible charge of a production department. Particularly familiar with combustion, high temperature fluidized bed operation, collection of organic solids from gases, fluid flow and purification of gases. Will relocate. Ch.Eng. Degree, 1936; age 36, married. Box 15-4.

Chemical Engineer — M.S.Ch.E., 1949, 27, single. Two years Navy electronics maint. Desire opportunity in production, product development, or chemical engineering research leading to possible future technical administration. Box 16-4.

Chemical Engineer—South American residing in California. M.S. Caltech 1949, B.S. in Chemistry. Six months' research experience. Desire development, production, or where Latin-American background would be advantageous. Box 18-4.

Chemical Engineer—B.S. 1949, M.S. June, 1950, Columbia. Tau Beta Pi. Veteran, 35 bombing missions, single, 26. Debating and writing experience. Prefer development or production in organics, petrochemicals or plastics. Box 19-4.

Industrial Research Group Leader—Research engineer. Twenty-two years' experience in guiding new projects from conception through final plant demonstration. Would prefer organizing permanent research group for medium size company. Box 20-4.

Chemical Engineer—B.S.Ch.E., 1942, Tau Beta Pi, age 32, married. Eight years' experience process development, design and operation in petroleum industry. Interested in any phase engineering offering real opportunity. Available immediately. Box 21-4.

Chemical Engineer — M.S.Ch.E., Univ. of Kansas, 1948. Single, age 26. One year in process development and pilot plant operation with large petroleum company. Desire responsible position in development, production, or process engineering. Available immediately. Box 22-4.

Chemical Engineer — B.S., Lehigh, 1941. Single, 28. 3½ years heavy chemicals production, instrumentation, electronics trouble shooting. 3 years fine chemicals pilot plant; small-scale process development, layout, operation, supervision. Desire pilot plant; development work. Prefer Northeast. Box 23-4.

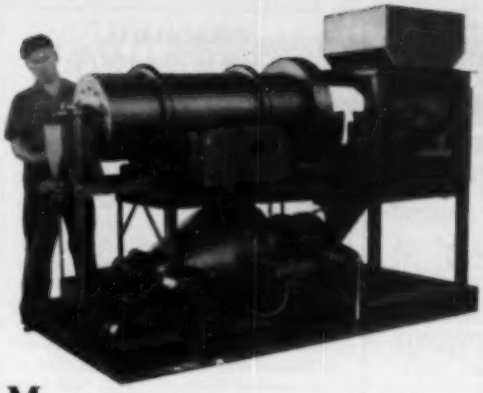
Chemical Engineer — M.S. January, 1947. Three years' experience in process development, large petroleum research organization. Design and supervision of pilot plants. Phi Lambda Upsilon. Interested in research and development in petroleum, organics, or plastics. Box 24-4.

Chemical Engineer — 26, B.S.Ch.E., 1947. Married, veteran, employed. 2½ years' experience exploratory and development work on thermal and catalytic reactions of petroleum hydrocarbons. Desire product development, sales, technical sales service or any position offering opportunity. Location secondary but prefer Midwest or Southwest. Box 25-4.

Chemical Engineer—M.S. Michigan, 1949. Four months petroleum chemist and nine months miscellaneous duties at synthetic fuels plant. Single, 25, mechanical ability. Desire position in development or technical service. Available immediately. Box 26-4.

Design and Construction Engineer—B.Ch.E. 1942. Eight years' experience in refinery, food processing and chemical plant design, operation and erection. Desire foreign employment. Box 27-4.

Academic Position Desired—Ph.D. in chem. eng. Family, 31. Seven years' varied industrial experience. Wish to divide time between teaching and fundamental engineering research. Will locate in United States or Western Europe. Box 28-4.



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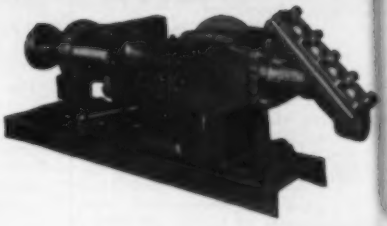

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PERSONALIA

(Continued from page 47)

G. J. ESSELEN HONORED

Dr. Gustavus J. Esselen, vice-president of United States Testing Co., in charge of the Esselen Research Division, Boston, Mass., was presented with honorary membership in The American Institute of Chemists, at the first meeting of the Institute's newly created New England Chapter, held at the Engineers' Club, Boston, March 20.

In 1930, he became president of the firm of Gustavus J. Esselen, Inc., consulting chemists and chemical engineers, in Boston, followed by the presidency of the Esselen Research Corp., which in 1949, became the Esselen Research Division of the U. S. Testing Co., Inc., with Dr. Esselen as vice-president.

Dr. Esselen is the author of numerous technical articles.

Andrew E. Chute has joined Arthur G. McKee & Co. as assistant technical director. He was formerly a senior process engineer with the Foster Wheeler Corp.

Nathan Shlechter, formerly assistant project engineer, Kellex Corp., New York, N. Y., is now employed by Ehrhart & Arthur of 417 S. Hill Street, Los Angeles, Calif., in the capacity of process engineer.

M. E. Spaght has been chosen by the Stanford (Calif.) Research Institute as a member of the recently formed technical advisory committee composed of nine leading scientists and research administrators in its San Francisco and Los Angeles areas of activity. Dr. Spaght is president of the Shell Development Co. The committee was formed by that Institute's board of directors to provide a regular independent review of activities in the organization's major fields of research, excepting those developments that are confidential in nature.

Harold C. Weber has been appointed special lecturer on the faculty of the University of Maryland. Without relinquishing any of his duties as professor of chemical engineering at the Massachusetts Institute of Technology, Professor Weber will visit at the Army Chemical Center, confer with the faculty of University of Maryland on the development of the program of instruction in chemical engineering at that center and will give a series of lectures and participate in the conduct of classes and seminars in chemical engineering there. Professor Weber was technical adviser of the commanding officer of the Chemical Warfare Service Development Laboratory at MIT during World War II.

William E. Ranz, who recently completed his work for a Ph.D. in chemical engineering at the University of Wisconsin, has joined the staff of the engineering experiment station, University of Illinois, Urbana, Ill. He will work on the unclassified AEC contract on fundamental studies of aerosols.

Robert M. Crawford, formerly vice-president Durez Plastics & Chemicals, is now engaged in business for himself as consulting chemical enginer. His headquarters will be at 160 Greenaway Road, Buffalo 21, N. Y.

E. W. Cook, formerly assigned to the New York (N.Y.) office of the Cyanamid Products Ltd., is now located in its London office at Brettenham House. Lancaster Place, London W.C. 2, England.

Alban J. Lobdell, formerly senior technician, Monsanto Chemical Co., St. Louis, Mo., is now research chemist to the research laboratory, Monsanto Chemical Co., Everett, Mass.

Paul Kolachov, director of research, Joseph E. Seagram & Sons, Inc., recently addressed two technical meetings in Florida. On Feb. 13 he spoke to the Florida section of the American Society of Bacteriologists at Florida State University, Gainesville, on "The Role of the Bacteriologist in Industry." On Feb. 17 Dr. Kolachov addressed the Mobile section of the American Chemical Society at Pensacola on "New Agricultural Corps for Chemical Raw Materials."

Necrology

ARTHUR E. GIBBS

Arthur E. Gibbs, of Wayne, Pa., retired since 1946, died after a brief illness at Summerville, S. C., March 2. He was 74 years old.

Mr. Gibbs was born in Bath, England. He was graduated from Bristol University in chemical engineering, and came to the United States in 1902, starting his electrochemical career at Niagara Falls. In 1903, he joined the Pennsylvania Salt Manufacturing Co. at its Wyandotte (Mich.) plant, where he invented and developed the Gibbs cell for the electrolytic production of chlorine, caustic soda and hydrogen from common salt brine.

In 1908, Mr. Gibbs organized the first separate research and development department of Pennsalt, at the Wyandotte plant, and this was moved to Philadelphia under his direction in 1912. He continued as head of this Pennsalt activity, and later as advisory technical director until his retirement in 1946.

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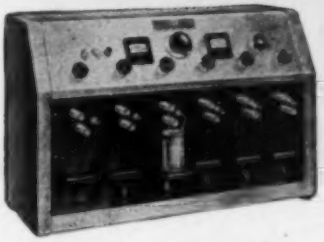

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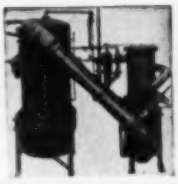
WHAT WILL SUMMER HOT WEATHER DO TO YOUR PROCESS



Croll-Reynolds CHILL-VACTORS frequently show a good profit over the total cost in extra production the first season, and they have many years of maintenance-free service. There are usually extra benefits in better quality and more uniform quality.

CHILL-VACTORS have many advantages, but are not perfect. In general, they are limited to temperatures above 32° F. They require more condenser water than mechanical refrigeration, but almost any natural water, including sea water, can be used. There are too many advantages to list here. The most important are:

Low cost • Can be operated by low pressure steam
No refrigerant except water • No moving parts,
Practically no operating supervision noise or vibration
Some liquids or solids can be cooled direct without brine or other circulating fluid

Made in sizes from a few tons to 1000 tons or more (1 ton = 12,000 B.T.U. per hour)

Individual engineering study will be given without obligation to each industry. This also applies to any industrial vacuum requirement down to a few microns absolute pressure.

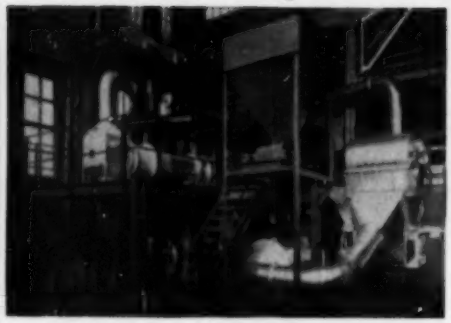
CROLL-REYNOLDS CO., INC.

17 JOHN STREET, NEW YORK 7, N. Y.

CHILL-VACTORS STEAM JET EVACTORS CONDENSING EQUIPMENT

CROLL REYNOLDS

You Don't Guess HOW



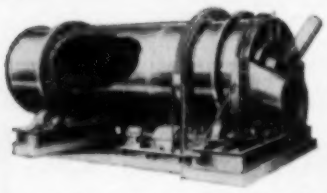
You KNOW exactly HOW!

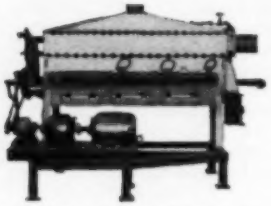
...a test run of your own material in the **LINK-BELT DRYER LABORATORY** tells you how to **DRY** or **COOL** or **PROCESS** for best results...

Now you can pre-determine the best method for achieving the drying, cooling and processing results you want. Link-Belt Research Engineers invite you to ship your material to the Link-Belt Drying Laboratory for a series of test runs. They invite you to cooperate with them in determining the proper type of equipment and procedures — *which can then be duplicated in your plant.* The Link-Belt Laboratory removes the "guess-work."

A test run can be arranged at your convenience. Simply write or phone the nearest Link-Belt Plant or Office. Send for catalogs.

LINK-BELT • COOLERS •





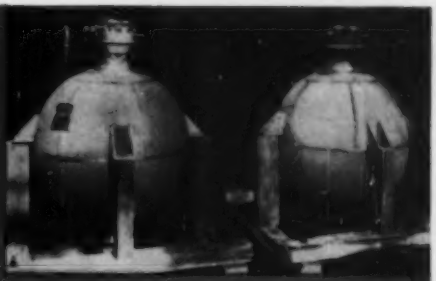
LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

11.821

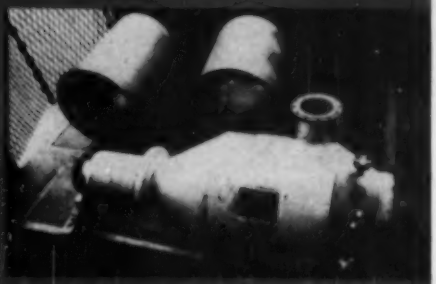
Present-day equipment design of chemical process vessels frequently requires something more than just another tank. Vulcan handles many such design and fabrication problems and is providing numerous special purpose vessels to process users. Three recent examples are illustrated.

Not just another tank!

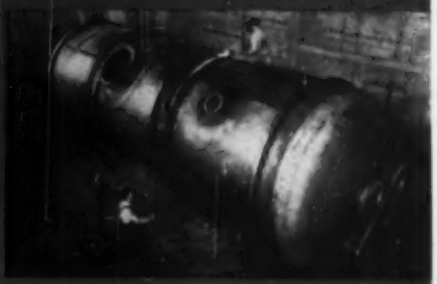
Items such as flash coolers, reactors, deaerators, percolators and separators are constructed. Often storage drums and tanks require special features. Complete evaporation units single or multiple effect, natural or forced circulation, are built. The individual items — bodies, calandrias, heat belts — also are available. Comparison on cost can be made between any of the metals — solid, clad or lined — through Vulcan's wide range of experience in alloy as well as copper and steel fabrication. Acetic acid, ethylene glycol, isopropanol, fatty acids and pharmaceuticals are typical products being handled in Vulcan-built equipment.



Three 12' diameter 304 stainless steel spheres are for the storage of condenser chemicals, with an operating temperature of minus 35° F. and a pressure of 300 psig. The welding of the 12 spherical segments to form each tank was performed in accordance with Paragraphs U-69 and U-140 of the A.S.M.E. Code.



A unit of Anti-evaporator Units — 12" in height, 42" and 24" in diameter, built of 1/4" thick type 316 extra low-carbon stainless steel. Use of expansion joint simplified at difficult piping problem on the circulating pump piping.



A horizontal sterilization kettle — 24' in length by 10' 6" in diameter, built of 3/4" thick deoxidized copper using the silver brazing process. The vessel was tested at 10 psig. and "the steam alone at 250 psig. Total weight was 24,000 lb.

VULCAN distillation evaporation extraction processes and equipment

THE VULCAN COPPER & SUPPLY CO. General Offices and Plant CINCINNATI, OHIO

SAN FRANCISCO NEW YORK BUENOS AIRES

IN CANADA — VICKERS VULCAN PROCESS ENGINEERING COMPANY LTD — MONTREAL

PILOT PLANT

PROCESS DESIGN

MECHANICAL DESIGN

SHOP FABRICATION

FIELD ERECTION

INITIAL OPERATION

ANIMAL PROTEIN FACTOR

from a new, cheaper source

How Swenson helped a manufacturer develop

an important ingredient for livestock and poultry feeds

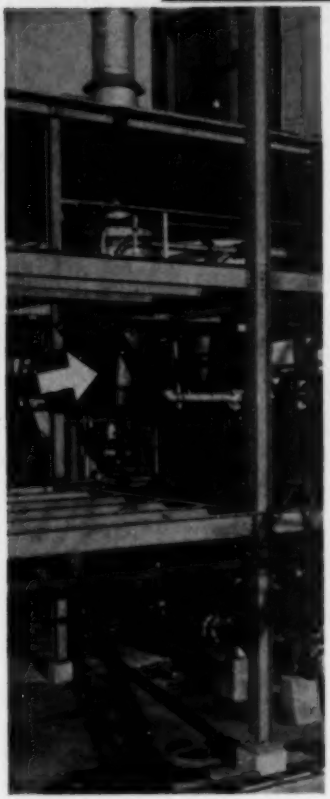
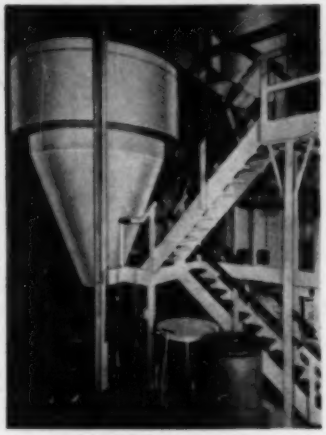


Photo of new Pfizer plant, taken during latter stages of construction. Arrow indicates part of Spray Dryer installation.

Biochemical research demonstrated to Charles Pfizer & Co., Inc., that certain fermentation processes could be utilized to synthesize the valuable Animal Protein Factor. But to market this material it had to be in dry form.

Test runs of the liquid in Swenson's commercial scale laboratory proved that spray drying could be used successfully—the finished powder retained virtually all of the desirable elements.



Main drying chamber of a Swenson Spray Dryer used in the manufacture of Upjohn pharmaceutical products.

So they installed Swenson Spray Drying Equipment, which is now in regular production. While this equipment was being installed, they made use of Swenson's custom drying service to handle carload lots of the material, thus getting immediate production.

Various other materials are being handled successfully with Swenson Spray Dryers—including substances used for human consumption, such as cascara extract and other pharmaceuticals.

If you have a material which offers unusual drying problems, it will pay you to consult Swenson engineers and make use of their testing facilities.

SWENSON EVAPORATOR CO.
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Eastern Sales Office and Export Department: 30 Church Street, New York 7, N. Y.
In Canada: Whiting Corporation (Canada) Ltd., 47-49 Leffmore Ave., Toronto 3